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AGEING AND HEALTH LITERACY

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Summary of the portfolio

Part A Comprises a systematic search of databases and review of peer-reviewed literature concerning executive functioning, health literacy and ageing. The paper aimed to build on a previous review to identify how poorer health literacy, advancing age and deteriorating executive functioning processes may relate to one another. Conceptual and methodological shortcomings were considered in light of a quality checklist and the implications for future research and clinical work were discussed.

Part B A quantitative study that compared how older and younger people performed on a health information task when stimuli were presented to single audio and visual sensory channels (using audio and text stimuli), and when stimuli were shown to both at the same time (using a video). The findings suggested that older participants performed approximately as well as younger participants when shown information by video, however they performed more poorly than younger people when only shown audio or text stimuli in isolation. Implications for future research and practice were considered.

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Section A: Literature Review

Executive functioning, ageing and health literacy: A literature review

Word count: 7,813

Abstract

Cognitive theories of ageing suggest that executive functions are very vulnerable to age related decline. These cognitive processes are implicated in tasks associated with independent daily living including managing one's health. Research indicates that older people's health literacy tends to be poorer than younger people's. This paper aimed to build on a previous review to identify how advancing age, health literacy and executive functioning processes may relate to one another. Electronic database searches of PsychInfo, Assia, Web of Science and Google Scholar were conducted and 16 papers were retrieved. The papers in this review suggest executive functioning, particularly working memory, may have a mediational role in the relationship between advanced age and poorer health literacy. However, the role of other cognitive processes such as processing speed, in addition to methodological shortcomings, limit conclusions that could be drawn. Implications for future research and clinical work are discussed.

Key words: Older adults, health literacy, executive functioning, working memory, processing speed

Introduction

Executive functioning

Executive functioning is an umbrella term for a set of cognitive abilities (Diamond, 2013). Those functions typically included are considered higher order; recruited in the pursuit of goal-directed behaviour and organising large volumes of complex and/or novel information for an intended purpose (Drag & Bieliauskas, 2009). Described most simply by Diamond (2013), they are the cognitive processes called upon when a task demand is beyond what can be managed by a routine or autopilot response (see Table 1 for a glossary of terms used within this review). Whilst a broad, goal-directed conceptualisation is widely agreed upon, there remains variation in the specific processes named as 'executive functioning' (McCabe, Roediger, McDaniel, Balota, & Hambrick, 2010). This has led to an array of neuropsychological tests asserting to measure executive functioning and its possible components (McCabe et al., 2010).

The extent to which the named processes are separate, distinct 'executive functions' or related by a shared component is also debated (Diamond, 2013). McCabe et al. (2010) assert executive functioning refers to: "inhibition of prepotent responses, shifting mental sets, monitoring and regulating performance, updating task demands, goal maintenance, planning, working memory, and cognitive flexibility, among others" (p.2). They attempt neutrality in referring to executive functioning as encompassing both "unity and diversity of function" (p.2). However, Follmer (2017) references weak correlations between executive functioning processes identified by some studies in asserting the independence of: inhibition, shifting, working memory, planning and attentional control as separate executive functions. In a comprehensive review of the literature, Diamond (2013) refers to both core and higher executive functions. Just as three primary colours are combined to create others, three core executive functions can be combined in the service of more elaborate processes such as reasoning, problem solving and planning. Diamond (2013) firstly refers to inhibition control. This encompasses both self-regulated response inhibition and filtering out interference through selective attention. Working memory was noted as a second core executive function and describes how information is held in mind for active manipulation. Lastly, cognitive flexibility was included and refers to the process of switching between tasks with different demands (Diamond, 2013). The author refers to these constructs as comprising a "family" of executive functions (p.1). That is, they are partially independent while also related to one another. In the absence of a definitive definition, Diamond's (2013) conceptualisation will be accepted within this review.

Table 1

Glossary of terms

Term	Definition used within this review
Health literacy	the ability to access, interpret and act on information to manage one's health (Cutilli & Bennett, 2009)
Executive functioning	A combination of individual but related core cognitive abilities: inhibition, working memory and cognitive flexibility, recruited in the pursuit of goal-directed behaviour and organising large volumes of complex information for an intended purpose (Drag & Bieliauskas, 2009; Diamond, 2013)
Working memory	Holding information in mind for rehearsal and active manipulation (Diamond, 2013)
Inhibition control	Self-regulating inhibition of response and ignoring environmental distractors through selective attention (Diamond, 2013)
Cognitive flexibility	Rapidly switching between tasks with different, sometimes opposing, demands
Inductive reasoning	A logical process of thought whereby generalisations are formed based on prior experiences, knowledge and observation (Diamond, 2013)
Attention	Selectively choosing one's focus of attention and suppressing attention to other details (Diamond, 2013)
Fluid abilities	Cognitions recruited for active information processing which are associated with learning and responding to novel stimuli (Diamond, 2013)
Crystallised abilities	Acquired skill and knowledge remaining relatively stable over time (Diamond, 2013)

Difficulties defining executive functioning and disentangling its components make measuring it a contentious issue. Instruments used will heavily depend upon the chosen definition, of which there are several (Diamond, 2013). However, it is generally agreed that the construct is too broad to be captured by a single assessment tool (Follmer, 2017). A prevalent criticism within the executive functioning literature concerns attempts to deduce performance based on one test that taps several processes simultaneously (Follmer, 2017). The single-test approach is most often used when theory-driven frameworks are lacking (Follmer, 2017) and further confuses issues with clearly naming and defining executive functioning processes, and establishing their unity or disunity. Similar criticisms have arisen when the same measurement tool is used to assess conceptually different processes (McCabe et al., 2010). For example, variations of the Stroop Task (e.g. Lezak, Howieson, & Loring, 2004) have been employed to gauge both response inhibition (Galvez-Garcia et al., 2017) and cognitive flexibility (Phillips & Bull, 2002).

Amongst the discord there is some consensus as to which measures assess which executive functioning processes. Reverse span tasks, for example, are generally accepted as appropriate assessments of working memory (Diamond, 2013) whereby recall is dependent upon reorganising the information presented. For example, repeating a string of numbers in reverse order. Verbal fluency tasks, for example naming as many items as possible belonging to a specified category, are also widely accepted measurements of inhibition control (Diamond, 2013). This is because it involves both inhibiting a response and inhibiting interference (Diamond, 2013). Assessments that involve switching between different tasks (such as the Trail-Making Test, Reitan, 1958) are accepted as assessing cognitive flexibility (Diamond, 2013; Follmer, 2017).

Executive functioning and ageing

Cognitive decline is an unanimously recognised consequence of advancing age (Niccoli & Partridge, 2012), although, normal ageing is not associated with deterioration in all cognitive abilities. Drag and Bieliauskas (2009) note some capabilities can even increase with age such as stores of factual knowledge and vocabulary. Others, conversely, are vulnerable to decline even in the absence of pathology (Niccoli & Partridge, 2012). Research into cognitive ageing has identified a disproportionate level of deterioration within the frontal lobes (e.g. Macpherson, Phillips, & Della Sala, 2002; Braver & West, 2008). Executive functioning processes were originally grouped based on their shared reliance on structures within the prefrontal cortex (McCabe et al., 2010). The frontal-ageing hypothesis which posits executive functioning as residing structurally within the frontal lobes, bears the brunt of age-related cognitive decline (Braver & West, 2008), particularly within the dorsolateral region (Macpherson et al., 2002). Frontal-ageing theories are supported by both neuroimaging studies highlighting greater structural deterioration in the frontal lobes relative to other areas (Raz & Rodrigue, 2006; Raz, Rodrigue, Kennedy, & Acker 2007), and neurocognitive studies showing a reduced or eliminated effect of age on a range of tasks, when executive functioning performance was controlled for in analysis (e.g. Clarys, Bugaiska, Tapia, & Baudouin, 2009).

The problem of processing speed

Advancing age is recognised both intuitively and experimentally to negatively impact performance on many tasks (Drag & Bieliauskas, 2009). Some authors, however, attribute the decline to slowed processing speed rather than an undue deterioration in executive functioning per se (e.g. Salthouse, 1996; 2000). Processing speed refers to a domain general cognitive process which underlies many others. It is the speed with which cognitive operations can be executed and is also observed to decline with increasing age (Baudouin, Clarys, Vanneste, & Isingrini, 2009). It can be readily anticipated how slower processing speed could reduce the efficiency with which cognitive processes are carried out. In this way, impaired performance reflects not a degraded ability in itself, but that necessary computations occur too slowly to make appropriate use of information for a task's purpose (Albinet, Boucard, Bouquet, & Audiffren, 2012). Several studies have identified that controlling for processing speed reduces age differences both on recall and reasoning tasks (Albinet et al., 2012). Processing speed further complicates the relationship between ageing and executive functioning. It can be unclear which cognitive processes (if either) are foremost affected and therefore responsible for impairing performance (Salthouse, 2000; Albinet et al., 2012). The confusion is compounded by measurement of processing speed. Research has typically attempted to distinguish the roles of processing speed and executive functioning by assessing both and controlling for one or the other in analyses (Albinet, et al., 2012). In such papers, processing speed has most commonly been measured with a variation of the Digit-Symbol Modalities Test (Robbins et al., 1994) requiring numbers to be matched with predetermined symbols, similar to a code, as quickly as possible (Albinet et al., 2012). Recent research now highlights this could be an inappropriate and impure assessment of processing speed. Remembering which symbol pairs with which number also heavily recruits working memory and, therefore, executive functioning processes, in addition to relying on speed (Baudouin et al., 2009). It is difficult to identify the contribution made by each to impairing task performance.

Health literacy

Health literacy refers to the ability to access, interpret and act on information to manage one's health (Cutilli & Bennett, 2009). Recent definitions capture the necessary skill of using acquired health-related knowledge and go beyond being a passive recipient of information. The definition highlights the increasing expectation for health to be an individual responsibility, with a societal premium upon patients managing their health independently (McCormack, Thomas, Lewis, & Rudd, 2017). This approach to healthcare carries important and adverse consequences for those with poor health literacy. Typically, less affluent individuals with lower educational attainments are at greater risk of inadequate health literacy and experience worse health outcomes, including greater incidence of mortality (Berkman & Donahue, 2011). The demographic risk factors are compounded by age and older people are likely to have poorer health literacy than younger people (Baker, Wolf, & Feinglass, 2007). The complexity of western healthcare systems is a considerable disadvantage to older people, the demographic most likely to have healthcare needs (Kopera-Frye, 2017). They are required to navigate multiple appointments, medication regimes and act on additional medical advice (Baker et al., 2007). Concurrently, their cognitive capabilities to assist in managing such demanding tasks, such as executive functions, are depleting (Braver & West, 2008). Yet, any relationship between ageing, executive functioning and health literacy decline is poorly understood.

A recent review by Kobayashi, Wardle, Wolf and von Wagner (2016) confirmed the higher prevalence of inadequate health literacy among older adult Americans relative to other age brackets. The review also examined the role of normal age-related cognitive decline in the context of lower health literacy among older adult samples. A limited number of studies assessing both health literacy and cognitive process constrained the conclusions that could be drawn. Furthermore, studies tended to rely on standardised, written tests of health literacy that have not been adapted for older people (Saldana, 2012). The authors, therefore, reported a "probable" (p.452) relationship between cognitive ageing and health literacy decline. As no definitive association was found, the review did not attempt to infer which cognitive processes may be involved.

Aims of the current review

The frontal-ageing hypothesis identifies executive functioning processes as particularly vulnerable to age-related decline (Braver & West, 2008). Yet it is these cognitive abilities that are needed for acquiring and using complex information to manage one's health (Chesser, Woods, Smothers, & Rogers, 2016). It is therefore understandable that older people may have poorer health literacy than their younger counterparts (Kobayashi et al., 2016). However, controversy surrounding executive functioning processes and few studies measuring both cognition and health literacy identified previously, mean that our understanding of executive functioning in the context of health literacy research is limited. The current review aims to bridge this gap by exploring how executive functioning is understood in the health literacy literature with older people. It also intends to build on Kobayashi et al.'s (2016) previous review by examining how executive functioning, health literacy and ageing may relate to one another, and whether executive functioning could have a mediating role in the relationship between ageing and heath literacy decline.

Why this review is important

Current approaches to improving health literacy among older adults have had limited success (Clement, Ibrahim, Wolf, & Rowlands, 2009). Efforts have been concentrated on adapting written materials that are distributed to patients by, for example, reducing the complexity of language (Geboers et al., 2015; Chesser et al., 2016). While this may modestly improve accessibility of information (Chesser et al., 2016), it has been insufficient to meaningfully improve health outcomes (Clement et al., 2009). Definitions of health literacy have shifted from referring merely being provided with information, to learning and using it (Cutilli & Bennett, 2009). Yet, methods of intervention have been slow to reflect this. It has been suggested that failing to consider and accommodate for age-related cognitive decline, particularly of executive functioning processes (Chesser et al., 2016), has prevented knowledge from being sufficiently learned and/or subsequently enacted (e.g. Lindquist et al., 2011). A better understanding of how executive functioning is conceptualised within health literacy literature is an important first step towards identifying how these constructs, both subject to deterioration with age, could be related, and whether executive functioning decline could be mitigated to improve health literacy in older people. While Kobayashi et al.'s (2016) review was recent, it only included papers published up to 2013. The limited research constrained what could be deduced about how cognitive functioning, in a broad sense, related to older adults' poor health literacy. The current review therefore includes three papers also used in the previous review, in addition to 13 more recent studies centring specifically on executive functioning and its relationship with health literacy.

Method

Any paper published until the start date of the review (21^{st} October 2017) was accepted. The inclusion and exclusion criteria are listed in Table 2. An electronic search was undertaken of the following databases: PsychInfo, Medline and Assia. Google Scholar was also searched to highlight any other papers not already identified. Search terms used are highlighted in Table 3. Results from all database searches have been collated and are shown in Figure 1 which illustrates the search process in full. Kmet, Lee and Cook's (2004) appraisal criteria for quantitative studies (see Appendix A) was applied to the retrieved papers and each received a summary score expressed as a percentage. Scoring information provided by the authors is included in Appendix A. Papers scoring above 75 percent are considered high quality. Those scoring below this are considered poorer quality. The authors suggest papers scoring below 55 percent are of poor quality and may be excluded from reviews and meta-analyses.

Results

A summary of the 16 retrieved papers is in Table 4. The studies varied in their design, the components of executive functioning that were included, co-variables that were considered and how constructs were measured. The way executive functioning was conceptualised and assessed is described below. Findings about how executive functioning, ageing and health literacy might relate to one another are then discussed.

Table 2

Literature search inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Empirical studies Older adult sample Reported on a quantitative measurement of health literacy and at least one executive functioning component according to the paper's author and/or Diamond's (2013) definition Studies published in English	Measurement tools not clearly described or referenced Measured another cognitive process only, not executive functioning

Table 3

Terms used in literature search

Older adult OR Aged OR Senior OR Elderly OR Geriatric	AND	Health literacy OR Health competence OR Health knowledge	AND	Executive function* OR Cognitive flexibility OR Working memory OR Verbal fluency OR Inhibition

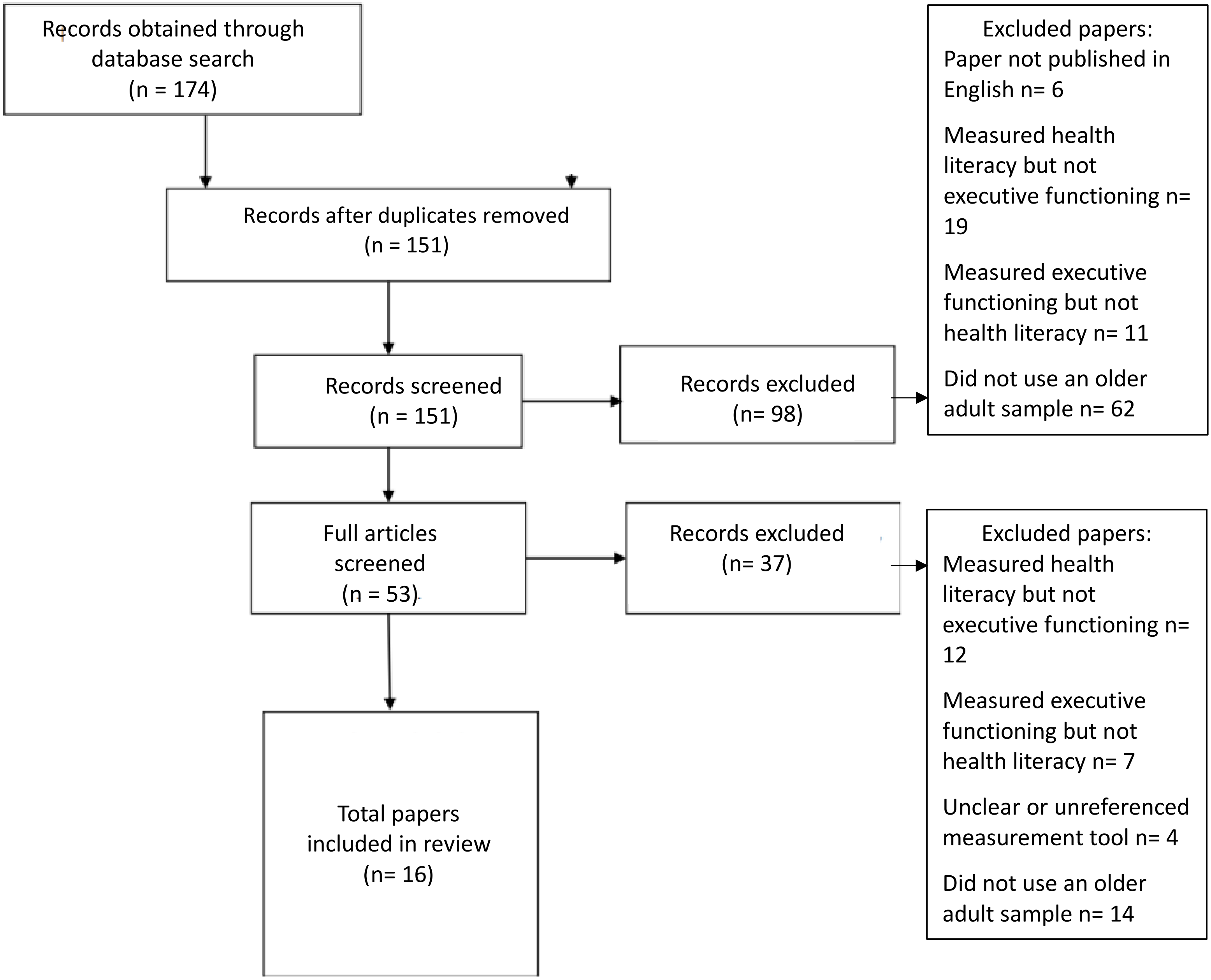

Figure 1. Literature review search method

Table 4

Summary of reviewed papers

Author & date	Sample	Design	Test of health literacy used	Executive functions measured (& tests used)	Co-variables included (& tests used)	Key findings	Quality score (%)
Boyle et al. (2013)	645 older adults, mean age 83.6 years	Longitudinal	Own measure comprising sections on health and financial literacy	Working memory (Reverse Digit-Span), attention (Digit-Symbol Modalities Test, Number-Comparison), verbal fluency (Animal Naming) and inhibition (Stroop Task). Scores composited into overall executive functioning	Age, ethnicity, gender, income level, education level, word knowledge	Better executive functioning performance was positively correlated with better health literacy The composite executive functioning score had a mediating effect on the relationship between older age and poorer health literacy No analysis of how individual components related to health literacy	86
Chin et al. (2017)	145 older adults, mean age 70.5 years	Cross-sectional	Short-Test of Functional Health Literacy in Adults (S-TOFHLA)	Working memory (Letter-Number Sequencing). Score composited into processing capacity	Age, education attainment, gender, diagnosis of hypertension Within processing capacity: processing speed (Pattern-Comparison), spatial ability (Hidden Pattern test and Card Rotation) General Knowledge (Advanced Vocabulary Test)	Health literacy score and processing capacity were negatively correlated with increasing age There was a significant association between better processing capacity score and improved health literacy	86

Chin et al. (2011)	146 older adults, mean age 69.6 years	Cross-sectional	S-TOFHLA	Working memory (Letter-Number Sequencing). Score composited into processing capacity	Age, education attainment, gender Within processing capacity: processing Speed (Number-Comparison, Pattern-Comparison). Visual perception (Finding As, Identical Pictures tests), Spatial ability (Card Rotation, Hidden Pattern test), Inductive reasoning (Letter-Sets). General Knowledge (Advanced Vocabulary Test, National Adult Reading Test)	Health literacy score and processing capacity were negatively correlated with increasing age There was a significant association between better processing capacity score and improved health literacy	86
Delazer, Kemmler & Benke (2013)	401 adults. 30.4% aged 50-59, 30.6% aged 60-69, 23.4% aged 70-79, 15.6% age 80-95	Cross-sectional	Own measure comprising numeracy tasks in a medical context (e.g. converting recovery percentages).	Cognitive flexibility (Trail-Making Test), verbal fluency (Animal Naming), Executive functioning (Frontal Assessment Battery), Working memory (author's own test of mental arithmetic)	Age, education attainment, gender Dementia screening score (Mini-Mental State Examination), motor speed (Trail-Making Test, A only), estimated verbal intelligence (a vocabulary task)	Higher age was negatively correlated with health literacy and performance on all cognitive tests apart from vocabulary There was a mediating effect of working memory and executive functioning on the relationship between higher age and poorer health literacy. There was no mediating role of verbal fluency in the relationship between age and health literacy	73
Federman,	414 older	Cross-	S-TOFHLA	Executive functioning and	Age, gender, ethnicity,	Poorer health literacy	68

Sano, Wolf, Siu & Halm (2009)	adults, mean age 73.6 years. 44% over age 75	sectional		verbal fluency (Animal Naming)	education attainment, English proficiency, income level, self-reported health status Immediate and delayed recall (Wechsler Memory Scale III Story A), global cognitive functioning (Mini-Mental State Examination)	was significantly positively associated with older age and worse performance on all cognitive measures Verbal fluency score was the strongest predictor of health literacy performance	
Ganzer, Insel & Ritter (2012)	58 older adults, mean age 80.4 years	Cross-sectional	S-TOFHLA	Working memory (Wechsler Memory Scale III working memory index)	Age, gender, ethnicity, education attainment, income level, mood (Geriatric Depression Scale) Immediate recall (5 warning signs of stroke) and delayed recall (repeated after 60 minutes), incidence of dementia (Mini-Mental State Examination)	Working memory performance was positively correlated with improved health literacy score and negative correlated with age Better working memory was significantly associated with improved recall of stroke warning signs	77
Gupta et al. (2016)	198 older adults, mean age 71.4 years	Longitudinal	S-TOFHLA	Executive functioning (Trail-Making Test)	Age, gender, education attainment, clinic location, mood (PHQ-9), smoking status, BMI, exercise frequency Crystallised functions (Controlled Oral Word Association Test, Animal Naming)	Poor (compared with adequate) health literacy was associated with a greater decline in score on the Trail-Making Test at 1 year follow-up. No such decline was observed on the Controlled Oral Word Association Test Rate of decline on the Trail-Making Test was	91

						mediated by age and ethnicity only	
Kobayashi et al. (2015)	774 adults aged 55-74, no mean reported	Cross-sectional	Test Of Functional Health Literacy in Adults (TOFHLA)	As part of fluid abilities: working memory (Reverse Spatial-Span & Size Judgement Task), inductive reasoning (Letter- Sets, Raven's Progressive Matrices, Stockings of Cambridge)	Age, gender, ethnicity, education attainment, income level, employment status, marital status, number of chronic physical health problems including depression As part of fluid abilities: Processing speed (Digit-Comparison, Pattern-Comparison, Digit-Symbol Modalities Test), Long-term memory (author's own wordlist recall task, New York Photograph Delayed Recall test), prospective memory (no test specified) As part of crystallised abilities: picture naming (Graded Naming Test), vocabulary knowledge (National Adult Reading Test)	Performance on all tests of fluid abilities declined with increasing age whereas performance on crystallised ability tests did not Processing speed had largest mediating effect on the relationship between ageing and health literacy performance followed by inductive reasoning, then working memory	91
Morrow et al. (2006)	314 adults aged 47-89 years, mean age 62.9 years	Cross-sectional	S-TOFHLA	Working memory (Reverse Listening- Span)	Age, education attainment, number of physical health conditions, auditory function (Speech Discrimination Screening Test), speech comprehension (Revised Token Test) Processing speed (Pattern-Comparison)	Improved working memory and processing speed scores were associated with better health literacy performance Working memory was a weaker predictor of health literacy score than	68

						processing speed and speech comprehension	
Nguyen et al. (2013)	537 older adults aged 60+ with diabetes	Cross-sectional	S-TOFHLA	As part of executive functioning: Verbal fluency (Animal Naming), attention (Brief Attention Test), working memory (Reverse Digit-Span)	Age, gender, education attainment, ethnicity, number of self-reported medical conditions, mood (CES-DS), diabetes duration, self-reported medication adherence, blood glucose level (finger-stick sample taken), Body-Mass Index, weight Incidence of dementia (Mini-Mental State Examination)	Improved performance on all cognitive tests was significantly associated with having better health literacy Working memory score was most strongly associated with health literacy score, followed by attention then verbal fluency performance	77
O'Conor et al. (2015)	425 older adults with asthma, mean age 68 years	Cross-sectional	S-TOFHLA	As part of fluid abilities: Working memory (Letter-Number Sequencing), executive functioning (Trail-Making Test)	Age, gender, ethnicity, education attainment, income level, number of chronic physical health conditions, compliance with asthma medication, inhaler technique (correct or incorrect) As part of fluid abilities: Processing speed (Pattern-Comparison), long-term memory (Wechsler Memory Scale III Story A), global cognitive function (Mini-Mental State Examination) As part of crystallised abilities: Verbal ability (Animal Naming)	Performance on all tests of fluid abilities were strongly positively correlated with improved health literacy. Verbal ability was moderately positively correlated with health literacy score The composite fluid ability score was a predictor of correct inhaler use	68
Sequeira et	226 older adults	Longitudinal	S-TOFHLA	As part of executive	Age, gender, ethnicity,	At baseline, age and	91

al. (2013)	aged 65+			functioning: executive function (Trail-Making Test), verbal fluency (Controlled Oral Word Association Test, Animal Naming & FAS)	education attainment, number of physical health conditions, mood (PHQ-9)	limited/inadequate health literacy were associated with poorer performance on executive function and verbal fluency tests At 12-month follow-up, significantly greater decline was found for performance on the Trail-Making Test but not verbal fluency in participants with poorer health literacy There was no difference between verbal fluency, executive function or working memory in explaining performance on the health literacy test	
Soones et al. (2017)	433 older adults with asthma, mean age 67 years	Cross-sectional	S-TOFHLA	As executive functioning: Trail-Making Test, Separate to executive functioning: working memory	Age, gender, ethnicity, education attainment, income level, asthma duration, experienced intubation (yes/no)	No difference was found between verbal fluency, executive functioning and working memory in terms of explaining differences in participants' health literacy score. Only age and ethnicity were identified as mediators Poorer performance on cognitive tests was significantly associated	86

				(Letter-Number Sequencing), verbal fluency (Animal Naming)	Immediate memory (Wechsler Memory Scale III Story A)	with inadequate/limited health literacy No difference identified between cognitive assessments and variation in health literacy score explained by each	
Wilson et al. (2010)	112 adults aged 40 – 85, mean age 51.4 years	Cross-sectional	Own tool, created by Boyle et al. (2013) as above	Working memory (Size Judgement Task)	Age, gender, ethnicity, education attainment, undergone colonoscopy in past year (yes/no), knowledge of colorectal cancer screening procedure Processing speed (Pattern-Comparison), long-term memory (New York Photograph Delayed Recall test), global cognition (Mini-Mental State Examination	Better working memory was associated with improved health literacy scores Working memory was more strongly associated with knowledge of colorectal cancer screening procedures than other cognitive processes measured (and the only one with a significant independent association)	81
Wilson, Yu, James, Bennett & Boyle (2017)	755 older adults, mean age 81.5 years	Longitudinal	Rapid Estimate of Adult Literacy in Medicine (REALM).	Working memory (Reverse Digit-Span, Digit Ordering), verbal fluency (Animal Naming)	Age, gender, education attainment, income level, number of chronic physical health conditions, financial literacy (% correct responses on test created for purpose of the study) Processing speed (Number-Comparison, Digit-Symbol Modalities Test), Immediate and delayed recall (	A stronger performance on all cognitive tests was associated with better health literacy and slower rate of decline at 12-months follow-up (excluding visuospatial abilities, which did not decline significantly)	95

					Wechsler Memory Scale III Story A & East Boston Story), Semantic memory (Boston Naming Test), Visuospatial abilities (Raven's Progressive Matrices, global cognition (Mini-Mental State Examination)		
Wolf et al. (2012)	882 adults aged 55 – 74, mean age 63.1 years	Cross-sectional	TOFHLA	As part of fluid abilities: working memory (Reverse Spatial-Span & Size Judgement Task), inductive reasoning (Letter-Sets, Raven's Progressive Matrices, Stockings of Cambridge)	Age, gender, ethnicity, education attainment, income level, employment status, marital status, number of chronic physical health problems, self-reported mood, mean number of prescription medications taken daily As part of fluid abilities: Processing speed (Digit-Comparison, Pattern-Comparison, Digit-Symbol Modalities Test), Long-term memory (wordlist recall, New York Photograph Delayed Recall test), prospective memory (no test specified) As part of crystallised abilities: picture naming (Graded Naming Test), vocabulary knowledge (National Adult Reading Test)	Better performance across all fluid abilities were associated with higher health literacy inductive reasoning was most strongly correlated with health literacy, followed by processing speed then working memory	77

Note. S-TOFHLA = Short-Test of Functional Health Literacy (Baker, Williams, Parker, Gazmararian, & Nurss, 1995); TOFHLA = Test of Functional Health Literacy (Parker, Baker, Williams, & Nurss, 1995), REALM = Rapid Estimate of Adult Literacy in Medicine (Bass, Wilson, & Griffith, 2003); Reverse Digit-Span (Robbins et al., 1994; Wechlser (1997); Digit-Symbol Modalities Test (Robbins et al., 1994); Animal Naming (Rosen, 1980); Stroop Task (Lezak, Howieson, & Loring, 2004); Letter-Number Sequencing (Wechsler, 2008); Trail-Making Test (Reitan, 1958); Frontal Assessment Battery (Dubois, Slachevsky, Litvan, & Pillon, 2000); Wechsler Memory Scale III (Wechsler, 1997); Reverse Spatial-Span (Robbins et al., 1994); Size Judgement Task (Cherry & Park, 1993); Letter-Sets (Ekstrom, French, & Harman, 1976); Raven's Progressive Matrices (Raven, 1976); Stockings of Cambridge (Robbins et al., 1994); Reverse Listening-Span (Wechlser, 1997); Brief Attention Test (Schretlen, Bobholz, & Brandt, 1995); Controlled Oral Word Association Test (Benton, Hamsher, & de Sivan, 1983); 'FAS' (Benton & Hamsher, 1976); Digit-Ordering (Cooper, Sagar, Jordan, Harvey, & Sullivan, 1991); Pattern-Comparison (Salthouse & Babcock, 1991); Number-Comparison (Salthouse, 1992); Hidden Pattern test (Ekstrom et al., 1976); Card Rotation (Ekstrom et al., 1976); Advanced Vocabulary Test (Ekstrom et al., 1976); National Adult Reading Test (Grober, Sliwinsk, & Korey, 1991); Mini-Mental State Examination (Folstein, Folstein, & McHugh, 1975); Geriatric Depression Scale (Brown & Schinka, 2005); PHQ-9 = Patient Health Questionnaire-9 (Kroenke, Spitzer, & Williams, 2001); New York Delayed Recall Photograph Test (Kluger, Ferris, Golomb, Mittelman, & Reisberg, 1999); Graded Naming Test (Robbins et al., 1994); Speech Discrimination Screening Test (Bayles & Tomoeda 1993); Revised Token Test (McNeil & Prescott, 1978); CES-DS = Center for Epidemiological Studies-Depression Scale (Blazer, Burchett, Service, & George, 1991); East Boston Story (Albert et al., 1991); Boston Naming Test (Welsh et al., 1994).

How was health literacy measured?

All papers included a health literacy assessment. Mostly, this was one of three standardised, written assessments: The Test of Functional Health Literacy (TOFHLA, Parker, Baker, Williams, & Nurss, 1995), the Short Test of Functional Health Literacy in Adults (S-TOFHLA, Baker, Williams, Parker, Gazmararian, & Nurss, 1995), or the Rapid Estimate of Adult Literacy in Medicine (REALM, Bass, Wilson, & Griffith, 2003). A brief description of these tests is included in Appendix B. Scores obtained on these instruments have been shown to correlate highly with one another (Kirk et al. 2012). Boyle et al. (2013) created their own, written, health literacy assessment with a subsection testing financial literacy. Delazer, Kemmler and Benke (2013) used a written assessment of health numeracy.

How was executive functioning conceptualised?

Of the 16 papers retrieved for the review, two offered a working definition of executive functioning. Boyle et al. (2013) conceptualised it as a higher order ability comprised of: working memory, attention, verbal fluency and inhibition. Definitions of each component process were also provided in the paper. However, no rationale for selecting this understanding of executive function was mentioned, nor was the overall definition referenced. Nguyen et al. (2013) also defined executive function as encompassing a range of cognitive processes. The concept was less succinctly and concretely defined relative to Boyle et al. (2013); and working memory was the only process tested that was clearly labelled. Others were mentioned in a more general sense, such as those required for “problem solving” (p.2).

A further four studies referred to the term ‘executive function’. Of these four, two mentioned the term and two listed examples of what the authors considered to be executive function processes. For example, Delazer et al. (2013) mentioned “set-shifting” and “mental flexibility" (p.641) though did not further interpret or operationalise the constructs. Two additional papers report executive function as though it were a single ability and provide no definition (e.g. Gupta et al., 2016). O'Conor et al. (2015) and Kobayshi (2015) include the term within the broader construct of "fluid ability" (e.g. O'Conor et al., 2015, p.1310). Fluid abilities were described as those required for active information processing, which are associated with learning and responding to novel stimuli. Collectively, fluid abilities were considered vulnerable to age-related decline. In addition to executive functioning processes like working memory and inhibition control, the term included others such as long-term memory (e.g. Kobayashi et al., 2015). Chin et al. (2011; 2017) refer to their own 'processing capacity model' that encompasses processes (e.g. inhibition control) recognised as executive functioning (Diamond, 2013), but without referring to the term.

How were executive functions measured?

Executive function as a single and composited ability.

Given the variation in how executive functioning has been defined, there was also disparity in the way it was measured. The papers identified a total of seven cognitive processes that either the authors assert to be executive functions, or have been recognised as such within Diamond's (2013) conceptualisation and therefore included within this review. This is summarised in Figure 2 with the various assessments used. Four papers such as Gupta et al. (2016) measured executive function as a single construct, rather than as a term to describe several processes, and it was assessed using a single test; the Trail-Making Test, TMT (see Appendix B for a summary of executive functioning tests used by papers within this review). Delazer et al. (2013) are an exception who utilised the TMT as a test of cognitive flexibility in addition to a specific executive functioning battery: The Frontal Assessment Battery (Dubois, Slachevsky, Litvan, & Pillon 2000). O'Conor et al. (2015)

measured executive functioning as a single entity which was included within a broader, fluid ability construct. Boyle et al. (2013), Nguyen et al. (2013) and Sequeira et al. (2013) composited scores from several tasks (e.g. working memory and attention) to provide an executive functioning index.

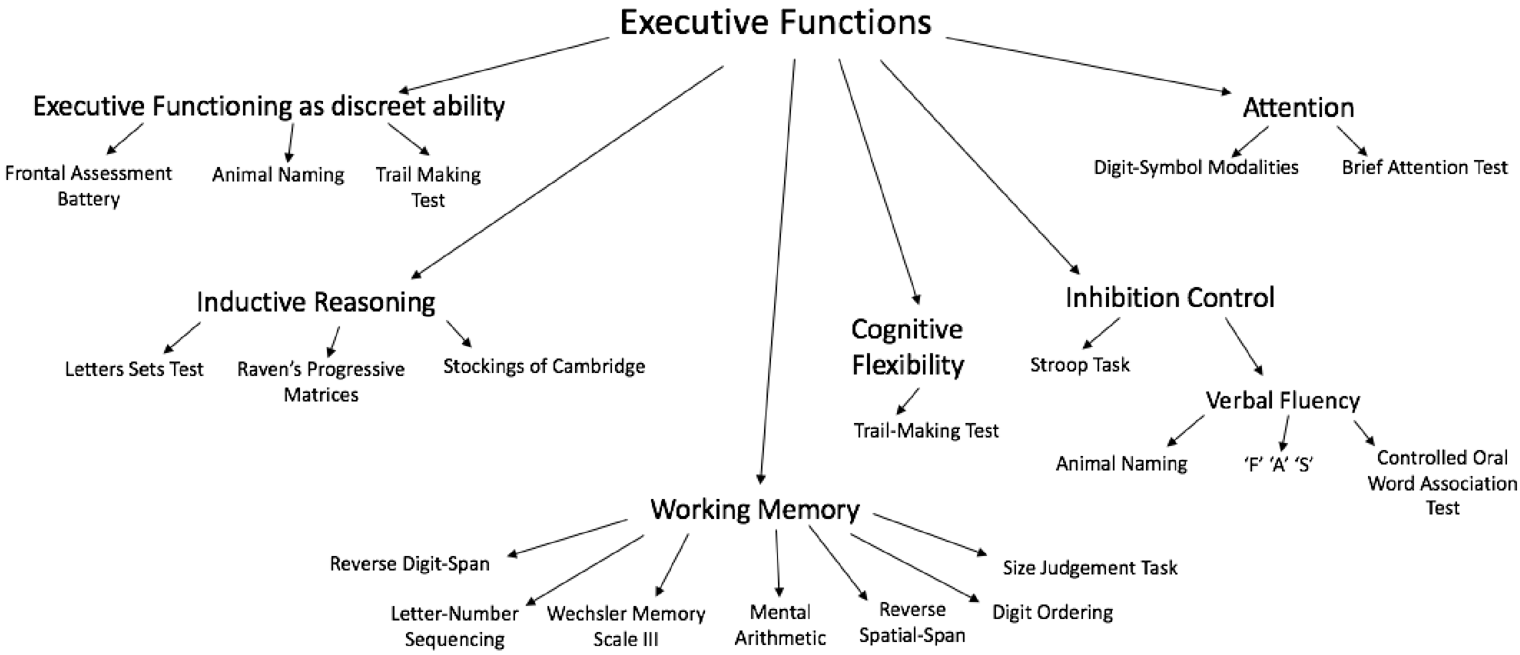

Figure 2. Executive functioning processes measured and tests used within reviewed papers

Working memory.

Working memory was the most commonly measured executive functioning process. Thirteen of the 16 papers reported using at least one of seven assessments. Most commonly, a variation of reverse recall span was used (e.g. digit, digit-letter or spatial) (Cooper, Sagar, Jordan, Harvey, & Sullivan, 1991; Robbins et al., 1994; Wechsler, 1997; Wechsler, 2008) and three papers used the Size Judgement Task (Cherry & Park, 1993). Delazer et al. (2013) and Ganzer, Insel and Ritter (2012) also included their own tests of arithmetic. Only Nguyen et al. (2013) and Boyle et al. (2013) assessed working memory within a broader executive functioning construct. Sequeira et al. (2013), who measured executive function independently, distinguished it from working memory, keeping the two separate. Some such as Chin et al. (2011; 2017), on the other hand, embedded it within their own model. Wilson and colleagues (2010; 2017) measured working memory independently where it was not summated into another, broader construct.

Inhibition control and verbal fluency.

Nine of the 16 studies included a measure of verbal fluency. None, however, reported it to gauge inhibition control, as is the case within the wider executive functioning literature (Diamond, 2013). All papers used a category naming task to measure verbal fluency (e.g. Animal Naming, Rosen, 1980, or words beginning with a given letter, Benton & Hamsher, 1976). The studies differed in the way verbal fluency tests were used. Federman, Sano, Wolf, Siu and Halm (2009) used the animal naming task as the sole measure of executive functioning. Nguyen et al. (2013), Boyle et al. (2013) and Sequeria et al. (2013) measured verbal fluency in conjunction with other processes such as attention and working memory that were composited to provide an overall executive functioning score. Sequeira et al. (2013) measured executive functioning separately from verbal fluency and other domains. Two papers also utilised tests of verbal fluency such as the Controlled Oral Word Association Test (Benton, Hamsher, & de Sivan, 1983) as a test of crystallised ability; acquired knowledge remaining relatively stable over time (Diamond, 2013). This contrasts with the seven other papers wherein verbal fluency was assessed precisely because it is vulnerable to age-related decline. Boyle et al. (2013) was alone in using the Stroop Task as a separate and explicit measure of inhibition control, while also including a verbal fluency test.

Other executive functioning processes.

Three studies used a measure of inductive reasoning. Inductive reasoning is defined by Diamond (2013) as a logical process of thought whereby generalisations are formed based on prior experiences, knowledge and observation. All three papers included it as a facet of some wider ability although none conceptualised this to be executive functioning. Chin (2011) included reasoning within their model of processing capacity and Kobayashi et al. (2015) and Wolf et al. (2012) measured inductive reasoning as part of fluid abilities. All three used the Letter- Sets test (Ekstrom, French, & Harman, 1976) and Kobayashi et al. (2015) and Wolf et al. (2012) also included the Ravens Progressive Matrices (Raven, 1976) and Stocking of Cambridge tests (Robbins et al., 1994). Ganzer et al. (2012) measured arithmetic as part of working memory. Delazer et al. (2013) also measured mental arithmetic in their study examining older adults' health numeracy. Both conceptualised arithmetic ability as a component of executive function. Attention was included by both Boyle et al. (2013) and Nguyen et al. (2013). While the latter measured attention with the Brief Attention Test (Schretlen, Bobholz, & Brandt, 1995), Boyle et al. (2013) utilised comparison tests and the Digit-Symbol Modalities Test. These were used by other authors to measure processing speed (e.g. Kobayashi et al., 2015).

Processing speed

In addition to executive functioning, processing speed was a commonly measured construct within the health literacy literature. Processing speed was measured in eight studies. Each study employed up to three processing speed measures from a range of four. All reported utilising a type of comparison test (either number or pattern) and Kobayashi et al. (2015), Wilson, Yu, James, Bennett and Boyle (2017) and Wolf et al. (2012) also included the Digit-Symbol Modalities Test. In two papers, processing speed was included within a broader construct and not reported on independently.

Is there a relationship between executive functioning and health literacy?

Variation in constructs (and combinations of constructs) that were measured, the names given to them and the assessment tools used, resulted in an array of findings about how executive functioning and health literacy may relate to one another. Papers naming executive functioning as a single ability will be discussed first, followed by separate executive functioning processes, where these have been related to health literacy individually. All papers controlled for demographic factors such as age, gender and educational attainments in analysis with some including additional variables such as ethnicity and mood factors (see Table 4).

Health literacy and executive functioning as a single process.

Of the studies that reported on a single, separate measure of executive function, all concluded that performance was in some way related to performance on a health literacy test. One paper noted weaker performance on the Trail-Making Test was significantly associated with poorer health literacy. In Gupta et al.'s (2016) research, poor health literacy was associated with a greater decline in cognitive flexibility (measured by Trail-Making Test score) at one year follow-up, irrespective of covariates such as educational attainments. Similarly, Sequeira et al. (2013) reported significantly greater decline in Trail-Making Test performance at follow-up for participants with more limited health literacy, relative to those with adequate health literacy. The authors identified no significant difference in the rate of decline on other tests, such as verbal fluency. They suggest that the Trail-Making Test is a purer measure of executive functioning, and that as a process, it is especially vulnerable to age-related decline. While this is in keeping with the frontal-ageing hypothesis, use of the test as a single and global measure of executive functioning may be unreliable, as it appears to capture one core process; cognitive flexibility (Diamond, 2013). The findings do suggest, however, that cognitive flexibility is more susceptible to the effects of cognitive ageing in older people with poorer health literacy relative both to other processes (such as inhibition control) and those with better health literacy.

Health literacy and executive function as a composited ability.

Sequeira et al. (2013) and two other studies reported findings of an executive functioning composite score. Boyle et al. (2013) identified a possible mediating role of executive function, comprised of: working memory, verbal fluency, attention and inhibition, on the relationship between higher age and poorer health literacy. Nguyen et al. (2013) reported independent associations between health literacy and each component of executive functioning measured: working memory, verbal fluency and attention. Overall, improved executive functioning was associated with better health literacy. These authors highlight executive functioning decline as a risk factor for low health literacy among older adults. These authors reported the most thorough conceptualisations of executive functioning and comprehensive testing battery to specifically measure executive functioning processes. The findings suggest age-related deterioration in executive functioning could be partially responsible for poorer health literacy seen among older people. However, it should be noted that none of the above papers measured processing speed; which may also account for the potential mediating effect attributed to executive functioning.

Health literacy and working memory.

Most studies that examined the relationship between working memory and health literacy reported an association. Some, such as Wilson et al. (2010), reported better working memory function was associated with improved health literacy and recall of health information. For others, participants with poorer working memory also tended to have poorer health literacy (e.g. Sequeira et al., 2013). While the literature agreed that older people’s working memory may be related to their health literacy level, there was variation in the strength of this association relative to other factors. Sequeira et al. (2013) found no difference between working memory score and executive function performance, or, what Diamond (2013) would refer to as cognitive flexibility (measured through a single test; the Trail-Making Test), in explaining the relationship between older age and poorer health literacy. However, Delazer et al. (2013) reported that working memory partly mediated the observed relationship between age and health literacy score in conjunction with another executive functioning assessment. Similarly, after controlling for 12 demographic covariates, Nguyen et al. (2013) reported working memory was a better predictor of health literacy score than attention and verbal fluency. Wilson et al. (2010) reported a stronger relationship between better working memory and improved health literacy, compared to other cognitive functions such as processing speed.

Conversely, Morrow et al. (2006) identified working memory as the weakest predictor of health literacy score. In this study, processing speed followed by a test of speech comprehension better explained individual differences in health literacy scores than working memory. Surprised by this finding, the authors suggest it reflects the low and limited range in their sample's performance on the working memory assessment and may not accurately reflect the relationship between working memory and health literacy. Kobayashi et al. (2015) and Wolf et al. (2012) also reported a weaker possible mediating role of working memory in the relationship between ageing and poorer health literacy relative to processing speed and inductive reasoning. It should be noted that these papers partly measured processing speed using the Digit-Symbol Modalities Test. This instrument is less often used within the executive functioning literature due to its reliance on working memory processes in addition to processing speed (Baudouin et al., 2009). As a result, it may be inaccurate to claim that processing speed played a larger role in explaining the relationship between age and health literacy than working memory. Taken together, the findings suggest that working memory may play a prominent part in the relationship between health literacy and ageing, in conjunction with other executive functioning processes. Methodological and sample differences (discussed further on page 35) could partly account for the mixed reporting of working memory's role.

Health literacy and verbal fluency.

Of the nine papers that assessed verbal fluency (indicating inhibition control, Diamond, 2013), two identified positive correlations between adequate health literacy and improved performance on verbal fluency tasks. A further four similarly reported positive correlations between limited or inadequate health literacy and poorer verbal fluency. Relative to other executive functioning processes, the findings were less varied in terms of the relationships reported between verbal fluency and health literacy. Sequeira et al. (2013) found no difference between verbal fluency, executive functioning and working memory in terms of explaining differences in participants' health literacy score. Delazer et al. (2013) identified no mediating role of verbal fluency in the relationship between age and health literacy, whereas working memory was reported as a potential mediator. Similarly, Nguyen et al. (2013) found verbal fluency score to be the least predictive of health literacy performance relative to working memory and attention. Participants with inadequate health literacy showed greater decline at 12 months on an assessment of cognitive flexibility (the Trail-Making Test), but not on verbal fluency in research by Gupta et al. (2016). The relationship between health literacy score and rate of decline appeared to be mediated only by baseline score and ethnicity. While Federman et al. (2009) reported verbal fluency was most strongly correlated with health literacy, it is important to note it was the only executive functioning component included in their analysis and is in comparison to scores on recall tasks and a dementia screening tool. Overall, participants scoring poorly on verbal fluency measures of inhibition control were more likely to have inadequate health literacy. However, inhibition control appears less important in explaining the relationship between health literacy and age compared to other executive functioning processes.

Health literacy and other executive functions.

Wolf et al. (2012) and Kobayashi et al. (2015) reported a relationship between inductive reasoning and health literacy. In both, participants with inadequate health literacy were likely to perform more poorly on inductive reasoning tasks, and vice versa. Wolf et al. (2012) also suggested inductive reasoning had a stronger relationship with health literacy relative to working memory and processing speed. Kobayashi et al. (2015) suggested some possible mediating effect of inductive reasoning on the relationship between age and health literacy, in addition to processing speed and working memory. Nguyen et al. (2013) also noted that participants with adequate health literacy were likely to perform better on their assessment of attention. These findings highlight the roles of other, higher order (Diamond, 2013) executive functioning processes. Given that few papers included them in analysis, it is difficult to ascertain their role in the relationship between health literacy and ageing. It is likely that processes such as attention will have been heavily recruited during tests of other components (Albinet et al., 2012). The role of inductive reasoning alone remains relatively unexplored. However, accepting Diamond's (2013) conceptualisation of executive functioning, any effect of a process such as inductive reasoning, is likely due to and so accounted for, by combining working memory, inhibition control and cognitive flexibility as core executive functions.

Health literacy and processing speed

Of eight papers that included a measure of processing speed, four reported findings examining the relationship between processing speed and health literacy. All reported a significant positive association between adequate, superior performance on health literacy tests and faster processing speed. Again, the papers differed in the way processing speed was related to health literacy relative to other variables. Morrow et al. (2006) suggested processing speed was the best single predictor of health literacy performance, more so than working memory. As described previously, this finding was unexpected and the authors suggest it may reflect a more limited range of scores achieved on the working memory assessment. Kobayashi et al. (2015) indicated processing speed was the strongest mediator of the relationship between health literacy and age and therefore played a larger mediating role than working memory and inductive reasoning. As mentioned, the measurement tool used in the paper may also implicate working memory and its validity as a measure of processing speed is therefore questionable (Baudouin et al., 2009). Conversely, Wolf et al. (2012) and Wilson et al. (2010) found a weaker relationship between better health literacy and faster processing speed, relative to executive functioning processes such as working memory and inductive reasoning. These findings suggest that age-related decline in processing speed has some impact on the relationship between age and health literacy. Whilst its impact may be less than executive functioning, issues with measuring and reporting prevent firm conclusions from being drawn.

Summary

The review considered how executive functioning is understood in health literacy literature with older adult samples. It identified several ways in which executive functioning has been conceptualised and measured as a whole, and in component parts. This review highlights how discrepancies in defining, naming and measuring executive functioning makes establishing its relationship with health literacy a difficult task. It has extended previous work (Kobayashi et al., 2016) by linking cognitive ageing, via executive functioning decline, with poorer health literacy. The reviewed papers suggest executive functioning decline may partially mediate the relationship between age and health literacy. From considering how individual executive functioning processes could relate to health literacy, working memory may have a prominent role. Cognitive flexibility could also be implicated in the relationship, and a possible role of inductive reasoning was identified. Inhibition control as assessed by verbal fluency appeared less important in explaining the relationship between lower health literacy and older age. The review also highlighted that slowed processing speed with advanced age may be related to poorer health literacy. Methodological issues and variation between papers limit the inferences that can be made, though it is possible processing speed plays a lesser role than executive functioning processes.

Research quality

The studies above have contributed to our understanding of how executive functioning is perceived in the context of older people's health literacy and how the constructs may relate to one another. However, the research was of variable quality. As shown in Table 4, papers utilised a cross-sectional or a longitudinal study design. Kmet et al.'s (2004) appraisal criteria for quantitative studies was used to gauge the quality of both, to allow for comparison. While some papers provided appropriate details of their participants, methodology and analysis, common issues were identified with the design, sample characteristics and limited reporting of (and controlling for) biases.

Design.

The design of papers was either cross-sectional or longitudinal. The 12 cross-sectional studies could investigate executive functioning and health literacy at a particular point in time, with a particular population (e.g. older adults with asthma, O'Conor et al., 2015). However, the design restricts conclusions that can be drawn about the direction of the relationship between executive functioning processes and poorer health literacy in older adults. Some, such as Kobayashi et al. (2015) reported the potential for cohort effects to have acted on the sample and Federman et al. (2009) postulate that the relationship is likely to be bidirectional. If this was recognised by other authors, it was not reported. Boyle et al. (2013) was alone in attempting to control for the prior rate of decline in executive functioning to better understand its relationship with lower health literacy in older age. Longitudinal papers were generally better placed to comment on the relationship between variables as comparing individuals over time, and with others, gleaned more information about how executive functioning might relate to health literacy among older people. This was particularly important here, given that several authors reported correlational analysis, which cannot infer cause and effect.

The papers differed in covariates that were measured and included in analyses. This applied to both components of executive functioning and demographic factors thought to influence health literacy. It limited how findings could be interpreted and compared across studies. This was especially true of those papers implying a mediational role of executive functioning on the relationship between health literacy decline and ageing. The internal validity of some studies was impaired by omitting measurement of and controlling for processing speed. While it was more explicit which executive functioning (and other cognitive) processes were assessed and included in analysis, this was not always the case for demographic factors. All papers did report incidence of dementia or cognitive impairment in their exclusion criteria. The impact of memory impairment beyond normal ageing was therefore controlled and unlikely to impact older participants' performance on health literacy or cognitive tests. Covariates such as age, gender and educational attainment were well controlled for in analysis. However, some studies, such as Nguyen et al.'s (2013), controlled for a total of 12 variables including, for example, participants' weight. Others did not control for mood (e.g. Boyle et al., 2013) which may have impacted upon findings of studies with between-subjects variables. Of the studies that did assess mood, the majority used a standardised instrument. While some then included the score as a covariate, others used it to screen participants out of the study. Using mood factors as an exclusion criteria limits the generalisability of findings and raises ethical questions as to how willing participants were sufficiently protected during this experience. The quality appraisal assessment (Kmet et al., 2004) highlighted a few methodologically robust studies, that spoke of, or attempted to address, possible collinearity between variables. However, this was not the norm and may be important to consider, given the difficulties in clearly separating, defining and measuring executive functioning and its components both in the reviewed papers, and wider executive functioning literature (McCabe et al., 2010).

Sample size and participant characteristics.

Generally, the papers used appropriately large samples. Their exact size, however was wide-ranging from 58 (Ganzer et al., 2012) to 882 (Wolf et al., 2012) This is perhaps due to a general reliance on convenience sampling, which may have biased findings. It could be particularly problematic when combined with inclusion criteria such as being under the care of a clinician in Kobayashi et al.'s (2015) research. Participants may be more motivated, or experience more physical health difficulties relative to others. Both factors could impact performance on effortful executive functioning and health literacy tests. Differences in age ranges between samples further limits how comparable findings are as both executive functioning (Braver & West, 2008) and health literacy (Kobayashi et al., 2016) are known to be more limited with increasing age.

Potential biases made the task of comparing studies challenging. As mentioned, measuring and controlling for differing covariates and sample characteristics mean comparison has the potential to be misleading. In understanding executive functioning in the context of health literacy, it is difficult to compare, for instance, middle-aged participants (mean age of 51, Wilson et al., 2010) with older participants (mean age 81 years, Wilson et al., 2017) as age is known to influence performance on tests of both executive functioning (Braver & West, 2008) and health literacy (Kobayashi et al., 2016). Whilst these biases may have been recognised, they were rarely commented on. Similarly, no papers reported counterbalancing executive functioning or health literacy assessments to account for fatigue effects. This may have impacted findings on some components measured as testing sessions could have lasted for up to an entire working day (Kobayashi et al. 2015).

Most papers measured health literacy using standardised written assessments or text-based experimental tasks. The health literacy tests used have not been validated with older adult samples (Saldana, 2012), which limits the conclusions that can be drawn. Differences in their demands on participants also highlight a disparity in the abilities recruited to aid performance. For example, the TOFHLA and S-TOFHLA include a combination of numerical and text comprehension exercises, such as reading a sample medicine label to calculate the recommended dosage amount and frequency of consumption. These assessments aim to capture a range of abilities referred to within definitions of health literacy (Saldana, 2012). The internal and external validity of these assessments is likely to be improved relative to the REALM health literacy assessment, a reading test of words used within medical settings. However, the ecological validity of written health literacy assessments in general requires consideration. Public Health England (2015) notes an assumption that non-adherence to health advice among older people could be attributed to limited health literacy and a lack of understanding, rather than a conscious choice to disregard health information and act autonomously. There is increasing attention directed to investigating strategies that may improve health literacy, given links between improved health literacy and positive health behaviours (e.g. Sheridan et al., 2011; Geboers et al., 2015). However, it remains important to acknowledge the complex and multifaceted systems impacting behaviour, that mean accessing and understanding information does not necessarily result in acting on it (Public Health England, 2015).

Also, evidence suggests that older adults may be disadvantaged by information presented in text form (Kunter, Greenberg, Jin, & Paulsen, 2006) and to only one sensory system (de Dieuleveult, Siemonsma, van Erp, & Brouwer, 2017). The tests used within the reviewed papers may not sufficiently consider the impact of cognitive ageing (Chesser et al., 2016), and so may not truly reflect older people's health literacy. A reliance on written materials may have further affected the performance of any participants with poorer general literacy, meaning they were additionally disadvantaged.

The quality appraisal tool (Kmet et al., 2004) also highlighted limited reporting of how attrition was managed in longitudinal studies. Particularly in health-related research, there is likely to be a difference between participants who remained in the studies and those who did not (Hagger-Johnson, 2014). Data is therefore from only the most motivated and willing older adults who may have better health literacy.

Discussion

Executive functioning is responsible for higher order tasks such as self-maintenance of behaviour in the service of goals (Diamond, 2013). In line with some cognitive theories of ageing (Braver & West, 2008; Macpherson et al., 2002), collated findings from studies in this review implicate deterioration of executive functioning processes in the health literacy decline observed among older people. The review suggests that executive functioning is understood to some extent in the context of older people's health literacy. Its component processes may partially mediate the relationship between advanced age and poorer health literacy. This review extends the work of Kobayashi et al., (2016) by suggesting a relationship between health literacy and executive functioning as a broader construct in addition to some of its component parts. However, no one executive functioning process was identified as responsible for the possible relationship and any association was complicated by simultaneous decline in processing speed, as well as conceptual and methodological shortcomings. As such, any conclusions must be accepted tentatively.

Limited accounts of executive functioning were provided within the health literacy literature. Differing definitions of the term and the component processes included by reviewed papers, mirrors disagreements evident within the wider executive functioning field (Diamond, 2013). Even in the two papers that attempted to define the construct, neither provided a rationale for the selected interpretation or the measured executive functioning processes. As the term was referred to within six additional papers, there were clear deficiencies in the way executive functioning was reported and operationalised within the health literacy literature.

The array of assessment tools used further highlights confusion around what executive functioning is and how to measure it. This was particularly evident where executive functioning performance was based on a single test. Such an approach may be considered insufficient within the wider literature (Follmer, 2017). A few papers composited test scores to provide an overall executive functioning score. Thus, it was sometimes conceptualised as a set of related components, similar to Diamond (2013). Most commonly, however, executive functioning processes were fractured and reported independently or as part of a different construct. It indicates they are more often considered distinct rather than united within the health literacy and ageing literature.

Differences in the tests (and number of tests) used to measure the same construct, made it challenging to compare the findings of papers within this review. It again implies confusion around defining and capturing executive functioning processes. Up to seven different measures of working memory, for example, were included by the studies. However, these were mostly appropriate and were often variations of the same task (e.g. backwards span tasks) accepted within neuropsychological literature (e.g. Diamond, 2013). Likewise, other measurements used were also mostly appropriate. There were a few notable exceptions. The Animal Naming test was a single assessment of executive function in Federman et al.'s (2009) study. The construct was therefore reduced to verbal fluency only. While the Animal Naming test is a recognised measure of inhibition control (Diamond, 2013), it was not used as such within any papers reviewed. In contrast, O'Conor et al. (2015) and Gupta et al. (2016) referred to Animal Naming as a test of crystallised ability. While the test draws upon crystallised abilities such as stored vocabulary, performance has been shown to decline with age (Albinet et al., 2012), indicating its vulnerability to the effects of cognitive ageing. Similarly, the Digit-Symbol Modalities Test could be regarded as an inappropriate measure of processing speed. Due to its simultaneous demands on working memory, the task may falsely inflate the role of processing speed relative to working memory and, therefore, executive functioning (Baudouin, et al., 2009).

Theoretical and research implications

These findings add to the body of literature linking poorer health literacy with advanced age and deteriorating cognitive skills (Kobayashi et al., 2016). Implications regarding the executive functioning literature are less clear cut. This review suggests a possible mediating role of executive functioning, yet identified support for both frontal lobe and processing speed theories of cognitive ageing. The picture is complex and it is likely that both play a role in health literacy decline with advancing age. Identifying the possible influence of either process was limited by papers suggesting a mediational role of executive functioning in how health literacy declines with age without also assessing (and controlling for the effect of) processing speed; and vice-versa. To clarify the relationship between cognitive ageing and poorer health literacy, it is imperative that future research sufficiently controls for well-established confounding variables.

Clearly defined constructs and appropriate assessment methods should also be used within future studies. This relates to executive functioning and other cognitive processes, but also to health literacy. All studies included in this review used written tests to gauge participants' health literacy level. While these standardised instruments enabled comparison between some studies, they may not fully reflect the active nature of health literacy and have not been validated for older adult populations (Saldana, 2012). It may be that written tests were considered the most ecologically valid means of assessing health literacy, as much health communication is via text-based materials (Kunter et al., 2006) and methods to improve older people's health literacy have focused on adapting written messages (Geboers et al., 2015). However, papers within this review were among those criticising such a simplistic approach to intervention (e.g. Wolf et al., 2012) which has shown limited success (Geboers et al., 2015). Some evidence suggests that written and other visual communications presented by themselves, could be less accessible to older people compared with other modalities (de Dieuleveult et al., 2017). A limitation of current research is therefore the exclusive use of text both to convey health information and to gauge older people's subsequent understanding and learning. Future studies should consider alternative means of communicating health information and assessing the extent to which knowledge is acquired. It may have important implications for making health information accessible and useable by older people.

Implications for clinical practice

Difficulties in drawing concrete conclusions within this review highlight the need to appropriately define and measure constructs and known confounds. This need applies within clinical practice as well as in research. Clinical Psychologists and Neuropsychologists should think about and critically reflect upon the assessment tools used to measure executive functioning processes. It is also important to remain aware of advances in the evidence base which may question the appropriateness of widely used tests. For example, variations of the Digit-Symbol Modalities Task are still sometimes used to measure processing speed, despite evidence that the test also draws upon working memory (Baudouin et al., 2009). The use of inappropriate assessments could provide misleading information about a client’s abilities leading to inaccurate formulation and misguided interventions.

In therapeutic practice, psychologists should consider the effects of cognitive decline when working with older adults. Research suggests that deterioration in both executive functioning and processing speed may reduce their health literacy. It is also likely to impair their engagement with cognitively demanding aspects of therapeutic work such as shared formulating, reflection and initiating change.

Conclusion

A number of authors hypothesise that cognitive ageing principally affects the frontal lobes and, therefore, executive functioning. Poor health literacy has also been widely associated with advanced age. This review sought to identify how executive functioning is understood in the context of older people’s health literacy. It aimed to further previous work by identifying how these constructs may be related. Variation in how executive functioning was conceptualised, measured and compared with other variables limits the conclusions that can be drawn. However, the review identified a possible mediating role of executive functioning in the relationship between advanced age and poor health literacy. Additional research is necessary to develop this understanding further. Studies within the review relied almost solely upon providing written material to convey health information and test health literacy. Such an approach may be disadvantageous to older people and interventions based on simplifying written text have failed to improve health outcomes. More diverse research is also needed to highlight new ways of communicating information to improve older adults' health literacy.

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Section B: Empirical Paper

Effects of age on a multimodal health information task

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Abstract

Background: Older people are more likely to have poorer health literacy, experience more health problems and worse health outcomes compared to younger people.

Aims: The aim of the study was to explore whether age differences between older people's and younger people's performance on a health information task would reduce with multimodal health information, presented by video, compared with unimodal information, presented by audio and text on their own.

Method: 24 older adults and 25 younger adults completed a test predictive of intelligence and an experimental task where they were shown information about health conditions presented by video, audio and text and then asked forced-choice questions about its content. Older adults also completed a cognitive screening test.

Results: No significant differences in performance between the age groups were found for video stimuli presentation. Conversely, older adults performed significantly worse than younger participants when shown the audio and text-based stimuli in isolation. The pattern of findings suggests the older group benefited more than the younger group from video stimuli.

Conclusions and implications: Older people may benefit more from receiving multimodal health information. Clinicians have a responsibility to communicate in ways most accessible to older adults. Additional work is needed to further investigate how presenting health information to more than one sensory channel could improve older people's health literacy and health outcomes.

Keywords: Older adults, health literacy, multisensory integration

Introduction

The ageing population

Increased life expectancy has been one of modern society's greatest successes (Oliver, Foot, & Humphries, 2014). At the time of the National Health Service's (NHS) inauguration (1948), almost half of the UK population died before reaching age 65 (Office for National Statistics, 2011b). Seventy years later, men are expected to live 19 years, and women 21 years, beyond 65 (Oliver et al., 2014). Recent census data suggests 10 million people living in the UK are aged over 65 years; approximately one in six citizens (Office for National Statistics, 2013e). The figure is expected to increase to 19 million by the year 2050 (Cracknell, 2010). As a consequence, older adults will comprise one in four people living in the UK and remain the fastest growing societal group (Cracknell, 2010). The number of people now living longer is considered "without parallel in the history of humanity" (United Nations, 2001, p. xxviii). It is a triumph that has transformed social and health care needs within the UK, and globally (Oliver et al., 2014). It is also a cause of concern for government bodies, policy makers (Kulik, Ryan, Harper, & George, 2014) and healthcare providers (Bloom et al., 2015).

Health and ageing

Growing evidence suggests that future generations of older people are likely to be more active and enjoy greater independence than their predecessors (Spijker & MacInnes, 2013). However, our vulnerability to disease, disability and frailty can increase with advancing age (Oliver et al., 2014). Those aged over 65 are at greater risk of developing a myriad of complex and co-morbid conditions including cancers and cardiovascular disease (Niccoli & Partridge, 2012). The ageing process is also associated with a decline in global functioning, including sensory sharpness (Freiherr, Lundström, Habel, & Reetz, 2013), and aspects of cognition (Niccoli & Partridge, 2012), even in the absence of neurological disorders. While stores of factual knowledge and vocabulary can increase (Drag & Bieliauskas (2009), the dynamic process of learning and appropriately using new information is sometimes more impaired with advancing age (Braver & West, 2008). This can limit how older people critically appraise and adapt to new information or environmental change, and can negatively impact their ability to care for themselves (de Dieuleveult, Siemonsma, van Erp, & Brouwer, 2017). Several theories have been suggested to explain age-related decline in functionality (de Dieuleveult et al., 2017). One possible explanation considers age-related deterioration of neurons within the frontal cortex, particularly the dorsolateral region (Macpherson, Phillips, & Della Sala, 2002) which neuroimaging (Raz, Rodrigue, Kennedy, & Acker, 2007) and behavioural studies (Clarys, Bugaiska, Tapia, & Baudouin, 2009) have linked to executive functioning. Executive functioning refers to a set of separate, though related, cognitive abilities recruited in the pursuit of goal-directed behaviour and organising complex information for an intended purpose (Drag & Bieliauskas, 2009). Executive functions are needed for all thought and action beyond what could be achieved with an automatic response (Diamond, 2013). Its components are therefore both essential for learning and tasks of independent daily living (Diamond, 2013), and vulnerable to decline with advancing age (Braver & West, 2008).

Older people and health literacy

Possible reductions in sensory sensitivity (Freiherr et al., 2013) and executive functioning (Braver & West, 2008) has implications for older adults' engagement with health services and health-related messages (Kopera-Frye, 2017). Data from the National Assessment of Adult Literacy (Kunter, Greenberg, Jin, & Paulsen, 2006) suggests that 38 percent of older adults have sufficient health literacy. Health literacy was measured through tasks assessing comprehension of prose, searching and navigating health-related documents, and computing numerical information. Those older than 60 years had lower levels of health literacy compared to younger age groups. This may be due, in part, to lower levels of general literacy identified amongst the older adult group (Kutner et al., 2006). Health literacy refers to the ability to obtain, retain and act on information to manage one's health (Cutilli & Bennett, 2009). This conceptualisation emphasises the importance of learning, so knowledge can be accessed for improved health outcomes (Cutilli & Bennett, 2009). The definition highlights a dominant expectation for health to be an individual responsibility that is managed independently (Chin et al., 2011). Such an approach to healthcare carries important and adverse consequences for older people, who can struggle with health literacy (Chin et al., 2011). Low health literacy is associated with increased likelihood of hospitalisation, difficulty managing chronic illnesses and increased rates of mortality (e.g. Baker, Wolf, & Feinglass, 2007). Older people therefore face an unfortunate paradox. Their vulnerability to a plethora of physical and cognitive illnesses increases with advancing age (Niccoli & Partridge, 2012), just as their ability to learn, understand (Braver & West, 2008) and make use of health-improving information declines. A recent review by Chesser, Woods, Smothers and Rogers (2016) corroborated previous findings of an association between older age and poorer health literacy. Older people with poorer health literacy also tended to experience worse health outcomes (Chesser et al., 2016). Cognitive decline was a cited risk factor for poorer health literacy, as were belonging to an ethnic minority or socioeconomic status group, and lower intelligence (Chesser et al., 2016). Public Health England (2015) recognise the contribution limited health literacy makes to increasing health inequality, as the individuals most likely affected share vulnerabilities such as fewer financial and social resources. The aim of improving health literacy is to mitigate the collective impact these risk factors may have on a person's health outcomes, given the infeasibility of removing the social and financial deprivation from which difficulties such as lower intelligence, often stem (Mantwill, Monestel-Umaña, & Schulz, 2015). Examining how they intersect in a health context specifically, hopes to illuminate avenues through which health information can be made more accessible, better understood and, ultimately, used for positive health outcomes (Public Health England, 2015).

Given the association between poor health literacy and worse health outcomes (Chesser et al., 2016; Baker et al., 2007), policy makers and researchers are more actively attending to the issue (McCormack, Thomas, Lewis, & Rudd, 2017). Broader influences of health literacy are being recognised beyond what can be expected of each patient independently. Providers and clinicians are being held more accountable for enabling access to services and ensuring health messages are appropriately communicated (McCormack et al., 2017). For example, the conceptual framework proposed by Paasche-Orlow and Wolf (2007) posits health literacy as a determinant of health outcomes, mediated by access to and use of healthcare, interactions with providers, and the ability to care for oneself. Access to healthcare and the ability to care for oneself are important considerations for older people's health. Restricted mobility and limited support disproportionately affect older people and impede their ability to engage with services and health-improving behaviours (de Dieuleveult et al., 2017). Most importantly, Paasche-Orlow and Wolf's (2007) model highlights the influence clinicians and healthcare systems exert on the uptake of services and health-related recommendations. System providers are responsible for ensuring that information is accessible and suitably tailored to maximally support patients in maintaining and improving their health (Paasche-Orlow & Wolf, 2007). This is particularly relevant to ensuring that older people have adequate health literacy.

Methods of improving health literacy

To date, efforts to improve health literacy have mostly focused on working-age adults with, or at risk of, limited health literacy and poor physical health (Chesser et al., 2016). A review by Sheridan et al. (2011) identified studies aiming to increase patients' knowledge and understanding of health information. Strategies included amending the design of written documentation to more easily compare health-plan options (Greene, Peters, Mertz, & Hibbard, 2008) and presenting the most important information first (Peters, Dieckmann, Dixon, Hibbard, & Mertz, 2007). The alterations produced only small improvements in patients' self-reported comprehension. Tait, Voepel-Lewis, Zikmund-Fisher and Fagerlin (2010) replaced written text with pictorial explanations of advantages and disadvantages of two drug types. While this led to improved general understanding of medication use overall, those with limited health literacy struggled with specific differences. Others added images to text-based messages (e.g. Garcia-Retamero, & Galesic, 2009) or replaced existing diagrams and symbols with alternatives (e.g. Peters et al., 2007). Sheridan et al. (2011) noted mixed and inconsistent results as to the success of these strategies in improving patients' health literacy. Effectiveness of the interventions also tended to be based on participants self-reporting a benefit, rather than on knowledge-based assessments. An intervention by Volandes et al. (2009), compared the effect of adding visual stimuli to an audio narrative (i.e. a video, versus audio) about palliative care options for terminally-ill patients. It was the only intervention to present multimodal information. There was a statistically significant difference in the care preferences expressed by those who had seen the video, compared to those who only heard the verbal narrative. Having watched the video, patients reported greater understanding and certainty about their choice of care and its implications.

Improving older people's health literacy

Previous work with older people has focused on identifying a relationship between increasing age and poorer health literacy (Chesser, 2016). A limited number of studies report on methods to improve health literacy specifically among older people. Geboers et al. (2015) identified several papers using similar strategies to interventions with adult samples. For example, adapting the design of written text by increasing font size and shortening health messages (Lee, Lee, Kim, & Kang, 2012). This approach has shown modest improvements in older adults' ability to understand written information (e.g. Morrow et al., 2006). Others attempted to customise material (Loke, Hinz, Wang, & Salter, 2012) and the way in which health professionals provide advice (Cavanaugh et al., 2009) for older adults with poor general literacy. Findings indicate that the almost exclusive focus on adapting written communications has been insufficient to aid older adults' learning and improve their health literacy (Clement, Ibrahim, Wolf, & Rowlands, 2009). Studies have also tended to judge an intervention's effectiveness by participant reports of how easy or difficult the information was to understand (Sheridan et al., 2011). Bickmore, Pfeifer and Paasche-Orlow (2009) adopted a more novel approach by connecting health literacy with health information technology. A computer agent was created to simulate face-to-face conversation. Little difference was found between participants with adequate and inadequate health literacy in terms of the tool's acceptability and usability. However, improving health literacy was not the focus of the research and it remains unclear whether the intervention benefited the adequate and inadequate health literacy groups. The study highlights the use of information technology within a health setting and its accessibility to older people. Previous studies have highlighted a greater difficulty among older adults to benefit from technological advances, particularly regarding the use of computers and accessing the internet (Jinmoo, Sanghee, Sunwoo, Hee, & Junhyoung, 2015). However, use of the internet is socially important in the lives of individuals across generations (Jinmoo et al., 2015). Tennant et al. (2015) assert that interest and proficiency in information technology skills is increasing among older people, particularly with regard to accessing and sharing health information. Research such as Bickmore et al.'s (2009) highlights the potential for information technology to be used successfully with this population in a health context.

Most previous work has targeted working-age adult samples and focused on adapting text-based messages. The impact of cognitive ageing has been under recognised (Chesser, 2016). Successful understanding and learning of health messages, relies upon cognitive processes that are vulnerable to the effects of age (Benson & Forman, 2002; Gazmararian et al., 1999), such as executive functions (Braver & West, 2008; de Dieuleveult et al., 2017). This is particularly true of comprehending written text, one of the most widely used means of disseminating health information generally (Kunter et al., 2006), and in methods adopted in the studies reviewed by Sheridan et al. (2011) and Geboers et al. (2015). However, a growing body of evidence highlights the disadvantage to older adults of single-modality messages that are accessible by one sensory system (de Dieuleveult et al., 2017), such as those provided in text only form. Only two studies have recognised the possible benefits of presenting information to both visual and auditory systems simultaneously (Volandes et al., 2009; Bickmore et al., 2009). Emerging research suggests that while individual faculties are vulnerable to decline with age (Freiherr, et al., 2013), older people may benefit even more than younger people from information presented multi-modally (Laurienti, Burdette, Maldjian, & Wallace, 2006; de Dieuleveult et al., 2017) Mozolic, Hugenschmidt, Peiffer, & Laurienti, 2012; de Dieuleveult et al., 2017).

Multimodal information and older people

To perform tasks of daily living, the brain integrates information taken from the environment by multiple sensory signals (de Dieuleveult et al., 2017). Older people may, therefore, appear disadvantaged; senses such as auditory perception (e.g. Liu & Yan, 2007) and visual acuity (e.g. Huberman & Danaf, 2015) are known to deteriorate with age. Older people have been shown to perform more poorly on separate tasks of visual and auditory detection (Peiffer, Mozolic, Hugenschmidt, & Laurienti, 2007), and localising targets within the environment (Dobreva, O'neill, & Paige, 2012) compared to younger people.

However, the availability of multimodal, audio-visual information has improved older adults' performance on a range of tasks assessing accuracy (Wu, Yang, Gao, & Kimura, 2012) and response time (Fiacconi, Harvey, Sekuler, & Bennett, 2013; Guerreiro, Eck, Moerel, Evers,

& Van Gerven, 2015) relative to unimodal, audio or visual information alone. Benefits of multimodal stimuli have also been identified for younger adults, although to a lesser extent (DeLoss, Pierce, & Anderson, 2013). Hunter, Phillips, & MacPherson (2010) demonstrated that older and younger people were better able to identify emotions expressed when congruent facial and vocal stimuli were presented together, than when a face or voice was shown in isolation. Furthermore, age differences in performance between older and younger participants were eliminated when information was presented multi-modally, whereas older people were impaired relative to younger people when only shown an auditory or visual stimulus.

Similar findings were reported by studies investigating the impact of visual-somatosensory information. Older adults' performance was improved when visual and somatosensory stimuli were presented together, compared to separately, and their performance was more improved than that of younger participants (Bates & Wolbers, 2014; Deshpande & Zhag, 2014). Authors suggest the effect may be due to the impact of ageing on neural processes that integrate information from different sensory channels (DeLoss et al., 2013; de Dieuleveult et al, 2017). This is known as multisensory integration (Laurenti et al., 2006; Mozolic et al., 2012). A principle of enhanced multisensory integration has been suggested to account for both older people's improved performance on tasks with multimodal, relative to unimodal stimuli, and their greater gains in performance, compared to younger people (Laurenti et al., 2006; Deloss et al., 2013). A review of the literature by de Dieuleveult et al. (2017), suggests that older adults may take in more of the sensory information available than younger adults, sometimes leading to a more improved performance when information is accessible by multiple sensory channels. Other theories propose the principle of enhanced multisensory integration is a compensatory strategy to offset age-related sensory impairment (Peiffer et al., 2007; Freiherr et al., 2013).

Rationale

Research suggests that older people may benefit when information is presented to multiple sensory systems (de Dieuleveult et al., 2017), and that doing so can reduce age differences on task performance (Hunter et al., 2010). To date, studies investigating the possible advantages of multimodal stimuli presentation have mostly been confined to examining object observation (Guerreiro et al., 2015), detection tasks (Wu et al., 2012) and emotion perception (Hunter et al., 2010; Freiherr et al., 2013). To my knowledge, the extent to which older adults may benefit from health information presented in a multimodal, audio-visual format, has yet to be explored. It may highlight alternative ways in which healthcare professionals can adapt communications to make health-improving information more accessible to older people. The proposed study aims to explore whether presenting health information multi-modally (video) benefits older adults' performance on a health information task more so than unimodal (audio or text) presentation. It was hypothesised that older adults would perform as well as younger adults on a health information task when information was presented by video. This will contrast with performance that is poorer than younger adults when information is presented by only audio or text in isolation.

Method

Design

A quasi-experimental, mixed-factor design was used with two groups of participants and no control group. Age group (older or younger) was the between-subjects independent variable. Mode of stimuli presentation (video, audio and text) was the repeated-measures independent variable. The dependent variable was the total number of correct responses to questions asked about health information for each modality of stimuli presentation.

Participants

Participants were recruited from regions in the South East of England and Channel Islands. All identified their ethnicity as White-British. Older adults were recruited through day centres (see Appendix C for the advertisement used to recruit both younger and older adults) and activity groups with the permission and support of staff and facilitators, who were made aware of the study inclusion criteria. Out of 32 older adult participants who consented to being contacted by the lead researcher, 24 participated. They were aged between 60 and 86 years with a mean age of 71.23 (SD 8.32). Attrition was due to inability to arrange a convenient time for participation, a lack of response to the researcher's contact or deciding not to participate. The younger adult comparison group was recruited via advertisements on social media platforms and word of mouth. Twenty-five eligible younger adults contacted the lead researcher and agreed to participate. They were aged between 18 and 37 years old, with a mean age of 26.04 years (SD 5.16). The older and younger adult groups were similar in terms of participants' gender and dominant hand. Ten males and 14 females comprised the older adult group, and 11 males and 14 females comprised the younger age group. Two participants from the older and three from the younger group were left-handed. Other demographic information is displayed in Table 1.

Individuals aged over 18 years, with normal or corrected-to-normal vision and hearing, those able to undertake a testing session lasting up to 45 minutes and whose first language is English were included. Individuals aged 60 and over and those aged 18 to 40 were eligible to participate in the older adult and younger adult groups, respectively. Age group parameters were chosen in line with previous research comparing the performance of older and younger participants, based upon the age at which cognitive changes associated with healthy ageing begin to occur (e.g. Hunter et al., 2010). Across both groups, participants were excluded if they self-reported a current psychiatric, neurological or developmental diagnosis, or taking medication that could impair their performance during the study. Participants were also excluded if they reported having greater understanding than would be expected in a 'general knowledge' sense of more than six of the health conditions forming the study stimuli. For example, through experiencing the condition themselves, caring for a loved one living with the condition or having worked in a health-related profession. Older adults were excluded if they obtained a score of 21 or below on the Mini-Addenbrooke's Cognitive Examination (M-ACE; Hsieh et al., 2015) as indicative of possible dementia. No participants contacted by the researcher were excluded based on the criteria described.

Table 1

Means and standard deviations for participant variables

	Older Adults (n = 24)		Younger Adults (n = 25)	
	M	SD	M	SD
Age (years)	71.23	8.32	26.04	5.16
Converted ToPF score	102.01	9.28	104.23	7.04

Note. M = mean; SD = standard deviation

Materials

Health information stimuli

The stimuli used in the study were 16 different passages of information about health conditions developed by Lui, Kemper and Boviard (2009). Health conditions included multi-infarct dementia and diabetes, for example (see Appendix D). Lui et al.'s (2009) health texts were selected based upon their relative brevity, which allowed several to be read, watched or listened to in a single testing session and which limited participant fatigue. The information passages had been analysed previously using Coh-Metrix Software (McNamara, Louwerse, Cai, & Graesser, 2005) to ensure similar word frequency, text cohesion and grammatical complexity (Lui et al., 2009). A male and female actor were video recorded reciting each of the information passages to develop the video and audio stimuli. Each piece of health information was presented for between three and four minutes. Participants were required to utilise the information to answer six forced choice questions about its content immediately afterwards. They responded with "yes", "no" or "don't know". Questions were asked in the same format (video, audio, text) as the information was presented and one point was awarded for each correct response. All participants were twice presented with information in each modality to yield a total possible score of 12. The modality of stimuli presentation was counterbalanced to account for possible fatigue effects. Following Lui et al.'s (2009) procedure, written stimuli was presented on A4 paper in font size 14. The actor's gender was randomly allocated in the video and audio trials to account for the impact gender may have on a participant's performance (Vatakis & Spence, 2007).

Neuropsychological Assessment

Mini-Addenbrooke's Cognitive Examination (M-ACE)

To exclude those with general cognitive impairment which would be likely to impact performance, older adult participants completed the Mini-Addenbrooke's Cognitive Examination (M-ACE; Hsieh et al., 2015). It is a brief assessment of general cognition and an abbreviated form of the Addenbrooke's Cognitive Examination – III (Mioshi, Dawson, Mitchell, Arnold, & Hodges, 2006). Subtests include orientation (maximum score of 4), clock-drawing (maximum score of 5), immediate verbal memory (maximum score of 7), category fluency (maximum score of 7) and delayed verbal memory (maximum score of 7).

Scores obtained on individual subtests are summed to yield a total score out of a possible 30. Hsieh et al. (2015) recommend a cut-off score of 21, which provided a sensitivity to dementia of 61% and specificity of 100%. Based upon the Mini Mental State Examination (Folstein, Folstein & McHugh, 1975), the M-ACE has both good concurrent validity (r = .83) and internal consistency (α = .83).

Test of Premorbid Functioning (TopF)

The Test of Premorbid Functioning (ToPF) (Wechsler, 2011) was used to estimate participants' verbal intelligence, as demographics such as educational attainment or number of years in full-time education is difficult to meaningfully compare across young and old samples (National Education Centre for statistics, 1996). The ToPF is a reading test comprising 72 items. Single words were read aloud by participants and a point was awarded for each word pronounced correctly. The test contains items, such as "ceilidh", that violate grapheme-phoneme correspondence rules and require prior knowledge to answer correctly (Wechsler, 2011). The total score was converted into an estimate of verbal intelligence, based on comparison data of scores obtained on the Wechsler Adult Intelligence Scale- Fourth Edition (WAIS-IV, Wechsler, 2008). The ToPF has good split-half reliability (α = .92) and test-retest reliability (α =.89) (Wechsler, 2011). It also showed good concurrent validity with verbal subtests on the WAIS-IV (α =.75) (Wecshler, 2011).

Procedure

All older and younger adults who expressed an interest in participating were given more information about the study. Older and younger adults were given separate information sheets (Appendices E &F, respectively) about the research and what participating would involve, before they decided whether to take part. They were then approached by the lead researcher who provided additional information. The experimental procedure was piloted with two older adult participants to estimate its duration and ensure task demands were appropriate. No changes were made to the procedure based on the pilot, and so data from the two older adults were included in the analyses.

Prior to starting the experiment, participants were reminded of their right to withdraw at any time and without providing an explanation. The researcher suggested a break if a participant seemed distracted, fatigued or distressed. In the event of a rest break being accepted by the participant, the researcher checked whether the participant wished to continue. Participants completed the experiment at the site of the day centre or activity group they were recruited from, or within their own home. The local trust lone working policy was adhered to throughout to ensure safety.

All participants were shown a list of health conditions involved in the experimental stimuli and indicated any they felt they had greater understanding of than would be expected in a 'general knowledge' sense (Appendix G). Any identified conditions were then excluded and six were randomly selected using computer software to form the task stimuli. All participants gave written consent (Appendix H) and completed the ToPF prior to being shown the first health information stimulus. Older adults also completed the M-ACE before beginning the experimental task. Older adults completed the procedure in 35 to 45 minutes. Younger adult participants completed the procedure in approximately 30 minutes.

A laptop computer was used for presenting the video and audio condition stimuli. During trials with video stimuli, participants were seated at a table facing the laptop screen. For audio stimuli trials, the laptop was moved out of the participant's line of vision, with the screen turned off. Participants were asked whether the sound volume and, for trials using video, their view of the laptop screen was sufficient before beginning.

The data collected were anonymised by assigning participants an identification code. Consent forms were also anonymised. Hardcopy data were stored in a lockable draw. Electronic data were stored on an NHS Trust password protected and encrypted USB flash drive.

Ethical considerations

Ethical approval for the study was granted by Salomons Division of the Christ Church Canterbury Ethics Committee (Appendix I). Participants were considered eligible for the study based upon their ability to provide informed consent (Department of Health, 2007). All participants were able to understand the necessary information, retain and consider the information in order to arrive at a decision about whether or not they wished to participate. Information about what participation would involve was included in both older and younger adults' information sheets, and further discussion was had in person with the lead researcher. All participants communicated their willingness to take part in the study both verbally and in writing. As such, capacity was assumed in accordance with the Mental Capacity Act (2005). Written consent to participate was obtained in line with the Code of Research Ethics (British Psychological Society, 2015).

Older adults were aware that their participation would involve a cognitive screening test. They consented to take part in the study with the understanding that the test may suggest difficulties. It was explained that the M-ACE is not used in isolation as a diagnostic tool. Similarly, all participants consented to complete the ToPF, with the understanding that it provides an estimate of their verbal intelligence. They were advised of the option to contact the lead researcher to discuss the tests used, or for feedback following participation. No participants requested further information about the tests or their performance.

If participants felt uncomfortable or distressed by any of the health information stimuli, they were reminded of the option to discuss this with the lead researcher or lead supervisor if they wished to. No participants made contact to discuss concerns or indicated distress during the experimental procedure.

Permission was sought from Lui, Kemper and Boviard (2009) by the lead supervisor to use their stimuli. There is public permission to use the M-ACE and the appropriate, copyrighted, testing materials were used with the ToPF.

Analysis

An a-priori analysis of statistical power was conducted using G*Power. It indicated a minimum sample size of 24 participants would be necessary to confidently detect an effect of stimuli presentation mode on participants' performance. The analysis was computed with a medium effect size (0.5) and sufficiently high power (0.8, Cohen, 1992) for a repeated measures ANOVA, with alpha =.05.

IBM SPSS Statistics version 24 was used to store and analyse data. As the data met assumptions of parametric tests, a mixed Analysis of Variance (ANOVA) test was used to compare the performance of both participant groups across the three modalities of stimuli presentation. The way in which all participants' performance differed according to stimuli modality, and differences between age groups regardless of presentation mode, were further investigated with post-hoc t-tests. Bonferroni corrections were applied to the modality of stimuli presentation significance levels (a = .05 / 3 = .016) to account for the increased risk of a Type I error with multiple statistical tests (Field, 2013). ANOVAs with pairwise comparison post-hoc tests and Bonferroni adjusted t-tests were used to examine differing patterns of performance for older adults and younger adults across each modality of stimuli presentation. Lastly, one-way ANOVAs were used to investigate possible differences in demographic factors within each age group. Cohen's d and partial eta-squared effect sizes were reported for t-test and ANOVA analyses respectively (Field, 2013).

Results

A mixed 2 (age group: older and younger) X 3 (mode of stimuli presentation: video, audio or text) analysis of variance (ANOVA) was used to compare the number of correct responses given by both age groups, according to modality of stimuli presentation. The Kolmogorov-Smirnov test was used to assess whether data were normally distributed. As shown in Table 2, all test values were $p > .05$, indicating the parametric assumption of normality had been met (histograms are in Appendix J). Older and younger participants did not significantly differ on demographic variables of gender $\chi 2(1) = .02$, $p = .88$, handedness $\chi 2(1) = .18$, $p = .67$ or intelligence $t(47) = -.51$, $p = .61$. Analysis was not conducted on ethnicity, as all participants within both age groups identified as White-British.

Table 2

Kolmogorov-Smirnov Test results

Stimuli Presentation Mode	Age Group	Kolmogorov-Smirnov results Statistic	df	Sig.
Video				
	Older Adult	.153	24	.154
	Younger Adult	.147	25	.169
Audio				
	Older Adult	.173	24	.061
	Younger Adult	.144	25	.193
Text				
	Older Adult	.170	24	.071
	Younger Adult	.153	25	.132

Observed power for the ANOVA main effects and interaction (computed using alpha = .05) was 1.00, indicating that the analysis was sufficiently powered. The ANOVA identified a main effect of age group $F(1, 47) = 35.80$, $p < .001$, $\eta_p^2 = .43$, showing that the number of correct responses differed significantly between older and younger participants, irrespective of stimuli presentation mode. Older adults performed significantly worse than younger adults t(47), -5.98, p < .000.

A main effect of stimuli presentation modality was also found $F(2, 94) = 30.75$, $p < .001$, $\eta_p^2 = .40$, suggesting that the number of correct responses given by both older and younger adult participants combined, significantly differed depending on whether information was presented by video, audio or text. Bonferroni adjusted t-tests were carried out as post-hoc tests. They indicated that participants performed significantly better when information was presented by video compared with both the audio $t(48) = 6.98$, $p < .000$ and text $t(48) = 5.60$, $p < .000$ modalities. No significant difference was found between performance with audio stimuli compared to text $t(48) = 0.45$, $p = .65$.

Additionally, a significant interaction between modality of stimulus presentation and age group was found $F(2, 94) = 16.84$, $p < .001$, $\eta_p^2 = .26$. This highlights that the pattern of performance across each presentation mode was significantly different between the older adult and younger adult groups. That is, the impact of stimuli presentation modality on performance was dependent on age group, and vice versa.

Two one-way ANOVAs were conducted as post-hoc tests to investigate how performance differed for each age group, separately, according to modality of stimuli presentation. For the older adult group, there was a significant main effect of stimuli presentation mode. Therefore, older adults' performance significantly differed according to the way in which health information was presented $F(1.5, 46) = 75.726$, $p <.001$. Considering the partial eta-squared, a moderate-strong effect size was indicated $\eta_p^2 = .77$. Observed power for the main effect of stimuli presentation mode (computed using alpha = .05) was 1.00, suggesting the analysis was sufficiently powered. Bonferroni corrected post-hoc tests showed that older adults performed significantly better when information was presented by video compared to audio t(23) = 8.31, p < .000, and text t(23) = 9.810, p < .000. Older adults also performed significantly better with audio stimuli compared to text t(23) = 6.22, p < .000.

Younger adults' performance differed significantly between the modes of stimuli presentation F(2,48) = 6.24, p = .004, η_p^2 = .77, η_p^2 = .21. A small effect size indicates a smaller magnitude of difference between performances according to presentation mode in the younger adult, compared to the older adult group. Observed power for the main effect of stimuli presentation mode (computed using alpha = .05) was .88, suggesting that the analysis was sufficiently powered, though slightly less so compared to the older adult group. Bonferroni adjusted post-hoc tests show that younger adults performed significantly better when information was presented by video compared to audio t(24) = 3.62, p = .00. No significant differences were observed in their performance between video and text modalities t(24) = 1.18, p = .25 or audio and text t(24) = -1.78, p = .061.

Between-subjects t-tests were conducted as further post-hoc tests to directly compare the performance of older and younger participants on each modality of stimuli presentation. The t-test results suggest that older adults performed more poorly than did younger adults when information was presented by video t(47) = -2.13, p = .038, *d* = 0.61, audio t(47) = -2.70, p = .010, *d* = 0.77, and text t(47) = -7.84, p < .001, *d* = 2.25. The findings are represented in Figure 1. With Bonferroni adjustment applied, only those results achieving a significance level of p < .016 (p = .05 / 3) can be regarded as statistically significant. Therefore, older adults performed significantly more poorly than younger adults when information was presented by audio and text, but not video.

The findings suggest that older adults' performance was most similar to the younger adult group when information was presented by video compared to the other modalities, due to the absence of a reliable difference between older and younger adults' performance for video presentation mode and the smallest effect size, compared to audio and text.

Further analyses were also undertaken to detect any possible variation in performance according to demographic variables. This showed that there was no significant difference in performance between genders according to modality of stimuli presentation for either the older adult $F(1,22) = .77$, $p = .39$ or younger adult $F(1,23) = 1.17$, $p = .29$ groups. Similarly, no significant differences were found in performance according to recruitment location for either older adult $F(2,21) = .164$, $p = .85$, or younger adult $F(1,23) = .76$, $p = .39$ participants.

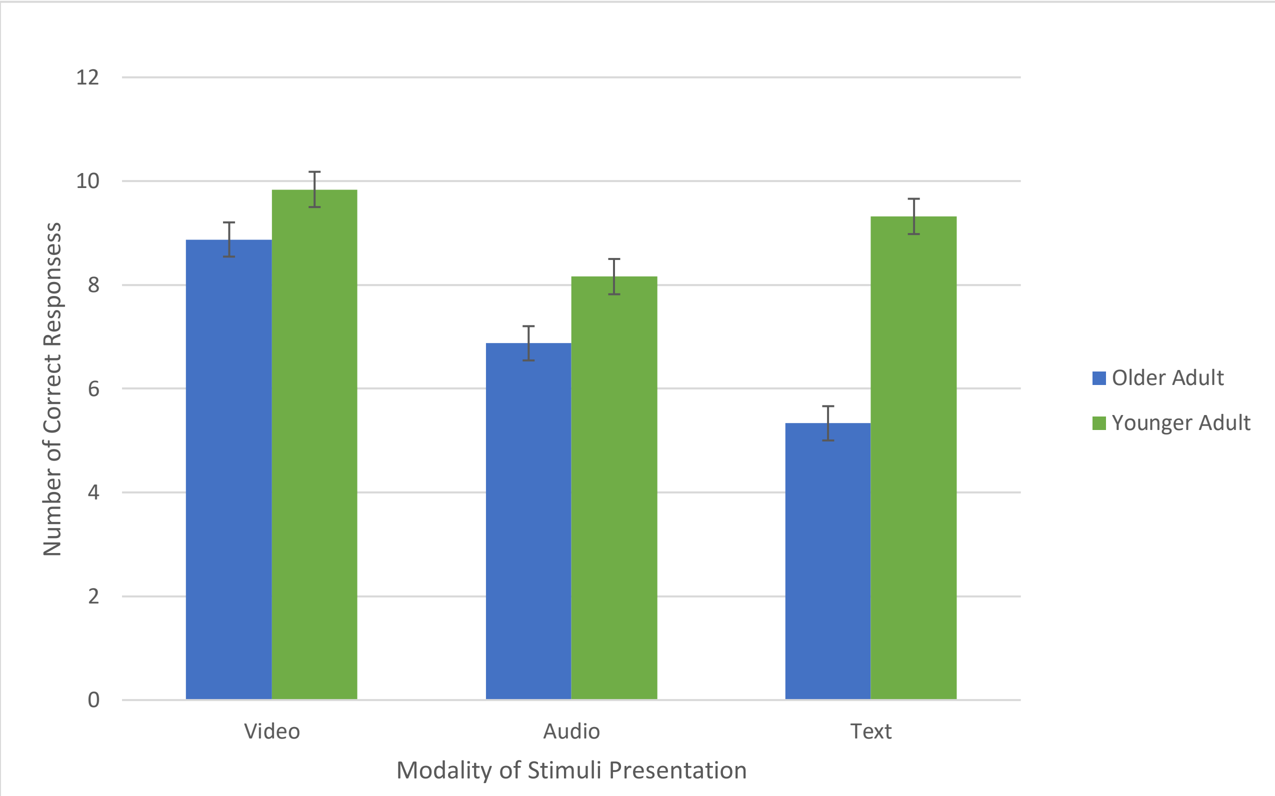

Figure 1. Correct responses for both age groups according to modality of stimuli presentation. Error bars indicate standard errors of the mean.

Discussion

This study aimed to identify whether older adults would perform as well as younger adults on a health information task when the information was presented multi-modally, by video; but less well than younger adults with unimodal stimuli audio or text, alone. The hypothesis was accepted. No significant differences in performance between the age groups were found for video stimuli presentation. Conversely, older adults performed significantly worse than younger participants with the audio and text-based modalities.

The results obtained here are in line with previous research. Firstly, they support those studies where older adults performed more poorly than younger adults across a range of tasks such as those requiring accuracy (Wu et al., 2012), speeded response time (Fiacconi et al., 2013; Guerreiro et al., 2015) and response adaptation considering novel information (Redfern, Jennings, Mendelson, & Nebes, 2009). Authors suggest this may reflect a greater difficulty among older adults to select their focus of, and sustain, attention (Fiacconi et al., 2013; de Dieuleveult et al., 2017), in addition to possible sensory impairment (de Dieuleveult et al., 2017).

This study also partly corroborates previous work highlighting the benefits of presenting information to multiple, compared to single sensory channels (DeLoss et al., 2013; Guerreiro et al., 2015). Video stimuli presentation improved aggregate performance on the health information task with older and younger participants' scores combined, compared to audio and text. However, while younger adults benefited from video stimuli presentation more so than audio, no reliable difference was observed in their performance between the video and text modalities. This contrasts with studies suggesting that performance of both younger and older people was significantly improved with multimodal stimuli compared to unimodal (DeLoss et al., 2013). Younger participants also tended to perform less well when information was presented audibly, suggesting that they may have found the listening task most difficult. In investigating age-differences in response to multisensory stimuli, Stine, Wingfield and Myers (1990) noted that younger participants performed more poorly on a recall task when information was presented via audio, compared with other single modalities.

In keeping with prior literature, older participants' performance in this study was significantly better when shown video stimuli compared to audio or text. It suggests that older people found the task easier when it was in video format relative to the other modalities. A number of previous studies also found that the performance of older adult participants was improved with, for example, multimodal visual-somatosensory (Bates & Wolbers, 2014; Deshpande & Zhag, 2014) and congruent audio-visual (Hunter et al., 2010) stimuli, compared to visual, somatosensory or audio information shown by itself. Furthermore, it was unsurprising that older adults performed poorest in this study when health information was presented by text, given the limited success of previous attempts to improve older adults' health literacy with solely written materials (Clement et al., 2009). The finding adds to evidence suggesting that health professionals could be unknowingly disadvantaging older people by presenting a large proportion of health-improving information to a single sensory modality (Chesser et al., 2016), particularly using text-based material (Clement et al., 2009; Kunter et al., 2006).

In addition to older people benefiting more from video, than audio or text stimuli, findings obtained here support the greater performance gains reported in previous research for older people compared to younger people, with the use of multimodal information (Diederich, Colonius, & Schomburg, 2008; DeLoss et al., 2013). That significant age differences in performance between the two groups were largely removed, suggests that older people benefited more from the video modality of presentation than did younger people.

De Dieuleveult et al. (2017) identified 21 experimental studies highlighting the greater benefits to older, compared to younger, adults of multimodal information across a range of tasks including object detection (Guerreiro et al., 2015), localising targets in the environment (Wu et al., 2012) and perceiving asynchrony (Chan, Pianta, & McKendrick, 2014). Mozolic et al. (2012) and De Dieuleveult et al. (2017) suggested that older people's enhanced performance could be explained by their experience of greater sensory "noise at baseline" (p. 9). That is, even when directing their focus of attention for a specific purpose, older adults can't help but take in extra information available in the environment. This is referred to as sensory noise. The noise can be useful when it becomes helpful for a task's purpose. However, it can be unhelpful when some of the information is irrelevant or unreliable (Mozolic et al., 2012; de Dieuleveult et al., 2017). Older people can be less adept than younger people at considering the relative importance of information entering their sensory systems (de Dieuleveult et al., 2017). They may therefore be poorer at identifying and ignoring irrelevant details, which can hinder their performance (Dieuleveult et al., 2017).

The increased "noise at baseline" hypothesis (de Dieuleveult et al., 2017, p. 9; Mozolic et al., 2012) may account for findings and trends observed in this study. Older people could have benefited more from the video stimuli than the younger comparison group if additional sensory noise was extracted and used in service of the task. Gleaning more information from the video may have helped older participants correctly respond to questions on its content and improved their performance. Thus, they benefited more from the multimodal stimuli than younger adults. It should be noted that while no significant difference between the age groups was found on performance with video-based stimuli, performance trends indicate that older people still tended to answer fewer questions about the stimuli correctly, compared to younger people. In keeping with Mozolic et al. (2012) and de Dieuleveult et al.'s (2017) greater "noise at baseline" hypothesis (p. 9), older people may have extracted irrelevant noise from the video in this study, as well as helpful information which could have increased their cognitive load and made the task more difficult. Being less able to identify and separate the useful details from the useless (de Dieuleveult et al., 2017), while also rehearsing the information for recall, may have contributed to trends showing an overall poorer performance for the older, compared to the younger, group.

An alternative theory suggests the principle of multisensory enhancement shown by older adults could be a means of compensating for age-related impairment in cortical responding to individual sensory stimuli (Peiffer et al., 2007; Freiherr et al., 2013). It follows the principle that "decreasing the effectiveness of individual sensory stimuli increases the magnitude of multisensory enhancements" (Mozolic et al., 2012, p. 37). The theory is based on findings from signal-detection tasks where older participants' performance was more improved than that of younger participants with multimodal stimuli, even when it was of low salience, for example, of weaker intensity or the multimodal components were ambiguously linked, than with high-salience, unimodal stimuli (Cabeza, Anderson, Locantore, & McIntosh, 2002; Peiffer et al., 2007; Freiherr et al., 2013). In this study, it could be that older adults performed significantly worse than younger adults when shown auditory or text-based stimuli independently, due to functional decline and reduced cortical responding to unimodal stimuli. An enhanced benefit of multimodal, video stimuli, could therefore have been found to compensate for a declined response to individual sensory channels (Cabeza et al., 2002; Freiherr et al., 2013).

In this study, gender had no impact on the performance of either age group. Female participants have performed better than males in other studies investigating the use of audio-visual stimuli and emotion recognition (Collignon et al., 2010). With an older adult sample, Hunter et al., (2010) found possible gender differences in emotion recognition, however limited statistical power prevented firm conclusions from being drawn. Much like the results seen here, gender differences in performance with multimodal stimuli have not been replicated following tasks without an emotional focus (Barnett-Cowan, Dyde, Thompson, & Harris, 2010).

Limitations and future work

Older adult participants in this study may be unrepresentative of the UK older population. All identified with belonging to a single ethnic group (White-British) which does not reflect the increase in cultural diversity seen in the UK as a whole (Cracknell, 2010). Older participants also may have belonged to a higher socio-economic status group, having been recruited from regions considered more affluent than the UK average (States of Jersey, 2017; Kent County Council, 2017). The inclusion criteria for the study also resulted in a relatively healthy sample both physically and cognitively which may not reflect the level of wellbeing experienced by the older adult population overall. It means findings cannot be generalised to older people with, for example, dementias and other neurological conditions the targeted population may experience (Niccoli & Partridge, 2012). Also, this study did not record demographic factors such as the number of physical health problems experienced by participants, their income level (Kobayashi et al., 2015), or mood variables (Gerber, Cho, Arozullah, & Lee, 2011) which may have affected how participants performed on the health information task. The repeated-measures aspect of the experimental design likely mitigated the possible impact of these variables on the study's findings. However, the external validity of future research could be improved by considering a fuller range of demographic variables that may be implicated in participants' performance. The older adult group within this study also spanned a large age range (60 to 86 years). Due to cognitive ageing, it is possible that, for example, participants aged 60 performed differently to those aged 80 on the health information task. This was not possible to explore due to an unequal distribution of ages within the older adult group. Future studies could investigate any possible variation in performance according to age within the older adult group, as well as in comparison to a younger sample.

This study has assumed, and relied upon, participants being motivated to perform to the best of their ability. The lead researcher conducted all data collection and was given no reason to question participants' attentiveness during the experimental task. Additionally, randomisation and counterbalancing protocols were utilised to reduce potential confounding factors. However, it is likely that participants were less motivated to perform well in this study than they would be if the information presented was needed to maintain or improve their health. The experimental task therefore lacked ecological validity. Future research may address this by recruiting through health services and identifying older people recently diagnosed with a physical health condition. Participants may be more motivated to learn the health information, although arising ethical issues would require careful consideration.

Further research may also test participants' performance at additional time points. It may be that a delay affects the enhanced benefit to older people of multimodal stimuli shown in this study. The performance of participants was only assessed immediately after each stimulus was shown. Little is known about how the modality of presented information might impact performance over a longer duration. This could be important in helping older people utilise acquired knowledge.

This was the first study to examine whether presenting information multi-modally could aid older adults' performance on a health information task. The nature of the task demanded participants to recall and manipulate information to correctly answer questions. While active involvement was demanded of participants, the task did not require enacting the learned information for a health-improving outcome. As such it did not fully capture all the dynamic aspects of health literacy. Future research could expand experimental tasks so as learning of health information is assessed by its active use in behavioural terms. Tasks specifically assessing executive functions or signal-detection could also be incorporated. This could help to clarify the relationship between the principle of multisensory enhancement and older adults’ cognitive load, or possible means of compensation for impairment in cortical response to individual senses (Freiherr et al., 2013).

Clinical implications

Findings from this study have implications for clinicians as to how health-improving messages are communicated. Given a clinician’s responsibility to provide appropriate and accessible information to older people (Paasche-Orlow & Wolf, 2007), they may wish to consider alternatives to written text. This study suggested that older people may benefit most from information presented multi-modally and least from solely written materials. The study also highlights the potential utility of information technology in a health setting, which may be helpful for disseminating health messages to older people. The findings could be relevant to all health professionals with client contact. While it would require further and more detailed exploration, use of the internet may provide a means of cost-effectively providing access to multimodal, video messages. Clinical psychologists could prioritise liaising with primary care colleagues, as older people will be most likely to attend their general practitioner to report a health complaint, in the first instance (Kopera-Frye, 2017). Clinical psychologists may also benefit from considering these findings in therapeutic work. It may particularly assist older people’s learning if concepts were reinforced with visual aids in tandem with verbal discussion.

Conclusion

This was the first study to examine whether presenting information by video could facilitate older people’s performance on a health information task more so than audio or text stimuli in isolation. Older people’s performance was improved with video stimuli compared with the other modalities. Moreover, age differences in performance between younger and older adults were reduced using video stimuli, whereas older participants were impaired compared to younger participants with audio and text alone. The findings carry implications for clinical practice, particularly regarding the way clinicians communicate health information to older people. More research is needed to investigate the possible enhanced benefits to older adults of presenting health information multi-modally, what is driving the effect and how it may support older people to achieve better health-outcomes.

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Appendix A - Quality assessment criteria for evaluating the quality of quantitative studies (Kmet, Lee & Cook, 2004)

Where a quality questions could be answered as “yes”, 2 points were awarded. Where a quality question could be answered as “partial”, 1 point was awarded. Where a quality question could be answered as “no”, 0 points were awarded.

The total number of points awarded to each paper reviewed were summed to provide a summary score. This was calculated as follows:

“Total sum = (number of “yes” * 2) + (number of “partials” * 1)

Total possible sum = 28 – (number of “N/A” * 2)

Summary score: total sum / total possible sum”

(p14; Kmet et al., 2004).

Quality assessment

1. Question or objective sufficiently described?

Yes: Is easily identified in the introductory section (or first paragraph of methods section). Specifies (where applicable, depending on study design) all of the following: purpose, subjects/target population, and the specific intervention(s) /association(s)/descriptive parameter(s) under investigation. A study purpose that only becomes apparent after studying other parts of the paper is not considered sufficiently described.

Partial: Vaguely/incompletely reported (e.g. “describe the effect of ” or “examine the role of ” or “assess opinion on many issues” or “explore the general attitudes”...); or some information has to be gathered from parts of the paper other than the introduction/background/objective section.

No: Question or objective is not reported, or is incomprehensible. N/A: Should not be checked for this question.

2. Design evident and appropriate to answer study question? (If the study question is not given, infer from the conclusions).

Yes: Design is easily identified and is appropriate to address the study question / objective.

Partial: Design and /or study question not clearly identified, but gross inappropriateness is not evident; or design is easily identified but only partially addresses the study question.

No: Design used does not answer study question (e.g., a comparison group is required to answer the study question, but none was used); or design cannot be identified.

3. Method of subject selection or source of information/input variables is described and appropriate.

Yes: Described and appropriate. Selection strategy designed (i.e., consider sampling frame and strategy) to obtain an unbiased sample of the relevant target population or the entire target population of interest (e.g., consecutive patients for clinical trials, population-based random sample for case-control studies or surveys). Where applicable, inclusion/exclusion criteria are described and defined (e.g., “cancer” -- ICD code or equivalent should be provided). Studies of volunteers: methods and setting of recruitment reported. Surveys: sampling frame/ strategy clearly described and appropriate.

Partial: Selection methods (and inclusion/exclusion criteria, where applicable) are not completely described, but no obvious inappropriateness. Or selection strategy is not ideal (i.e., likely introduced bias) but did not likely seriously distort the results (e.g., telephone survey sampled from listed phone numbers only; hospital based case-control study identified all cases admitted during the study period, but recruited controls admitted during the day/evening only). Any study describing participants only as “volunteers” or “healthy volunteers”. Surveys: target population mentioned but sampling strategy unclear.

No: No information provided. Or obviously inappropriate selection procedures (e.g., inappropriate comparison group if intervention in women is compared to intervention in men). Or presence of selection bias which likely seriously distorted the results (e.g., obvious selection on “exposure” in a case-control study).

4. Subject characteristics or input variables/information sufficiently described?

Yes: Sufficient relevant baseline/demographic information clearly characterizing the participants is provided (or reference to previously published baseline data is provided). Where applicable, reproducible criteria used to describe/categorize the participants are clearly defined (e.g., ever-smokers, depression scores, systolic blood pressure > 140). If “healthy volunteers” are used, age and sex must be reported (at minimum). Decision analyses: baseline estimates for input variables are clearly specified.

Partial: Poorly defined criteria (e.g. “hypertension”, “healthy volunteers”, “smoking”). Or incomplete relevant baseline / demographic information (e.g., information on likely confounders not reported). Decision analyses: incomplete reporting of baseline estimates for input variables.

No: No baseline / demographic information provided.
Decision analyses: baseline estimates of input variables not given.

5. Outcome and exposure measure(s) well defined and robust to measurement and misclassification bias? Were means of assessment reported?

Yes: Defined (or reference to complete definitions is provided) and measured according to reproducible, “objective” criteria (e.g., death, test completion – yes/no, clinical scores). Little or minimal potential for measurement / misclassification errors. Surveys: clear description (or reference to clear description) of questionnaire/interview content and response options. Decision analyses: sources of uncertainty are defined for all input variables.

Partial: Definition of measures leaves room for subjectivity, or not sure (i.e., not reported in detail, but probably acceptable). Or precise definition(s) are missing, but no evidence or problems in the paper that would lead one to assume major problems. Or instrument/mode of assessment(s) not reported. Or misclassification errors may have occurred, but they did not likely seriously distort the results (e.g., slight difficulty with recall of long-ago events; exposure is measured only at baseline in a long cohort study). Surveys: description of questionnaire/interview content incomplete; response options unclear. Decision analyses: sources of uncertainty are defined only for some input variables.

No: Measures not defined, or are inconsistent throughout the paper. Or measures employ only ill-defined, subjective assessments, e.g. “anxiety” or “pain.” Or obvious misclassification errors/measurement bias likely seriously distorted the results (e.g., a prospective cohort relies on self-reported outcomes among the “unexposed” but requires clinical assessment of the “exposed”). Surveys: no description of questionnaire/interview content or response options. Decision analyses: sources of uncertainty are not defined for input variables.

6. Sample size appropriate?

Yes: Seems reasonable with respect to the outcome under study and the study design. When statistically significant results are achieved for major outcomes, appropriate sample size can usually be assumed, unless large standard errors (SE > 1⁄2 effect size) and/or problems with multiple testing are evident. Decision analyses: size of modeled cohort / number of iterations specified and justified.

Partial: Insufficient data to assess sample size (e.g., sample seems “small” and there is no mention of power/sample size/effect size of interest and/or variance estimates aren’t provided). Or some statistically significant results with standard errors > 1⁄2 effect size (i.e., imprecise results). Or some statistically significant results in the absence of variance estimates. Decision analyses: incomplete description or justification of size of modeled cohort / number of iterations.

No: Obviously inadequate (e.g., statistically non-significant results and standard errors > 1⁄2 effect size; or standard deviations > _ of effect size; or statistically non-significant results with no variance estimates and obviously inadequate sample size). Decision analyses: size of modeled cohort / number of iterations not specified.

7. Analysis described and appropriate?

Yes: Analytic methods are described (e.g. “chi square”/ “t-tests”/“Kaplan-Meier with log rank tests”, etc.) and appropriate.

Partial: Analytic methods are not reported and have to be guessed at, but are probably appropriate. Or minor flaws or some tests appropriate, some not (e.g., parametric tests used, but unsure whether appropriate; control group exists but is not used for statistical analysis). Or multiple testing problems not addressed.

No: Analysis methods not described and cannot be determined. Or obviously inappropriate analysis methods (e.g., chi-square tests for continuous data, SE given where normality is highly unlikely, etc.). Or a study with a descriptive goal / objective is over-analyzed.

8. Some estimate of variance is reported for the main results/outcomes?

Yes: Appropriate variances estimate(s) is/are provided (e.g., range, distribution, confidence intervals, etc.). Decision analyses: sensitivity analysis includes all variables in the model.

Partial: Undefined “+/-“ expressions. Or no specific data given, but insufficient power acknowledged as a problem. Or variance estimates not provided for all main results/outcomes. Or inappropriate variance estimates (e.g., a study examining change over time provides a variance around the parameter of interest at “time 1” or “time 2”, but does not provide an estimate of the variance around the difference). Decision analyses: sensitivity analysis is limited, including only some variables in the model.

No: No information regarding uncertainty of the estimates. Decision analyses: No sensitivity analysis.

12. Controlled for confounding?

Yes: Randomized study, with comparability of baseline characteristics reported (or non-comparability controlled for in the analysis). Or appropriate control at the design or analysis stage (e.g., matching, subgroup analysis, multivariate models, etc). Decision analyses: dependencies between variables fully accounted for (e.g., joint variables are considered).

Partial: Incomplete control of confounding. Or control of confounding reportedly done but not completely described. Or randomized study without report of comparability of baseline characteristics. Or confounding not considered, but not likely to have seriously distorted the results. Decision analyses: incomplete consideration of dependencies between variables.

No: Confounding not considered, and may have seriously distorted the results. Decision analyses: dependencies between variables not considered.

13. Results reported in sufficient detail?

Yes: Results include major outcomes and all mentioned secondary outcomes.

Partial: Quantitative results reported only for some outcomes. Or difficult to assess as study question/objective not fully described (and is not made clear in the methods section), but results seem appropriate.

No: Quantitative results are reported for a subsample only, or “n” changes continually across the denominator (e.g., reported proportions do not account for the entire study sample, but are reported only for those with complete data -- i.e., the category of “unknown” is not used where needed). Or results for some major or mentioned secondary outcomes are only qualitatively reported when quantitative reporting would have been possible (e.g., results include vague comments such as “more likely” without quantitative report of actual numbers).

14. Do the results support the conclusions?

Yes: All the conclusions are supported by the data (even if analysis was inappropriate). Conclusions are based on all results relevant to the study question, negative as well as positive ones (e.g., they aren’t based on the sole significant finding while ignoring the negative results). Part of the conclusions may expand beyond the results, if made in addition to rather than instead of those strictly supported by data, and if including indicators of their interpretative nature (e.g., “suggesting,” “possibly”).

Partial: Some of the major conclusions are supported by the data, some are not. Or speculative interpretations are not indicated as such. Or low (or unreported) response rates call into question the validity of generalizing the results to the target population of interest (i.e., the population defined by the sampling frame/strategy).

No: None or a very small minority of the major conclusions are supported by the data. Or negative findings clearly due to low power are reported as definitive evidence against the alternate hypothesis. Or conclusions are missing. Or extremely low response rates invalidate generalizing the results to the target population of interest (i.e., the population defined by the sampling frame/ strategy).

Appendix B - Description of executive functioning tests referred to in the reviewed papers

Domain		Test Name	Author	Description
Health literacy		Rapid Estimate of Adult Literacy in Medicine (REALM)	Bass, Wilson & Griffith (2003)	Reading test comprised of 66 health-related words. Some violate grapheme-phoneme correspondence rules and require prior knowledge to answer correctly
		Short Test of Functional Health Literacy in Adults (S-TOFHLA)	Baker, Williams, Parker, Gazmararian & Nurss (1999)	A short form of the Test of Functional Health Literacy in Adults. It is comprised of 2 reading comprehension exercises and 4 multiple-choice numeracy questions about health information
		Test of Functional Health Literacy (TOFHLA)	Parker, Baker, Williams & Nurss (1995)	A reading comprehension and arithmetic ability test of medical information. It is comprised of 50 items
Executive functioning		Animal Naming	Rosen (1980)	A category fluency task. Participants are asked to vocalise as many different animals names as they can think of in 1 minute
		Frontal Assessment Battery	Dubois, Slachevsky, Litvan & Pillon (2000)	A brief screening tool with items examining fluency, abstraction, response time and impulsivity
		Trail-Making Test	Reitan (1958)	A 2-part visual-motor test. Participants must firstly join a set of dots numbered 1-25 as quickly and accurately as possible. They must then complete the task again alternating between numbers 1-13 and letters A-L
	Inductive reasoning	Letter-Sets	Ekstrom, French &	A series of letters are displayed according to a pattern, participants must identify the

		Harman (1976)	additional letter not following the pattern
	Raven's Progressive Matrices	Raven (1976)	Incomplete designs are shown and participants must select from several options which pattern would complete the set
	Stockings of Cambridge	Robbins et al. (1994)	Using as few moves as possible, participants must match a set of coloured balls with another moving each ball in turn
Working Memory	Digit Ordering	Cooper, Sagar, Jordan, Harvey & Sullivan (1991)	Participants must mentally reorganise a set of 7 numbers according to a rule
	Letter-Number Sequencing	Wechsler (2008)	Participants are read a combination of numbers and letters and must reorder them according to a rule
	Reverse Digit-Span	Robbins et al., (1994); Wechlser (1997)	Participants are shown a series of numbers and must reorder them in reverse, so the number that was shown last becomes first and vice versa
	Reverse Spatial-Span	Robbins et al. (1994)	Participants are shown a series of differently sized boxes and must reorder them in reverse, so the box that was shown last becomes first and vice versa
	Size-Judgement Task	Cherry & Park (1993)	Participants must read lists of differing lengths comprised of same-sized words and reorder them from shortest to longest list
	Wechsler Memory Scale-III	Wechsler (1997)	A set of visual and verbal tests of verbal and arithmetic ability, requiring participants to retain information for active manipulation to complete the tasks
Cognitive Flexibility	Trail-Making Test	See above	See above

Inhibition Control	Stroop Task	Lezak, Howieson & Loring (2004)	Participants must first read aloud written words of differently coloured ink. Using the same written words, participants must repeat the task vocalising the colour of the ink in which words are printed
Verbal Fluency	Animal Naming	See above	See above
	'FAS'	Benton & Hamsher (1976)	Participants are required to vocalise as many different words as possible in separate trials beginning with each of the letters: 'F', 'A' and 'S' in 1 minute
	Control Oral Word Association Test	Benton, Hamsher & de Sivan (1983)	Participants are required to say aloud as many different words as possible in 1 minute. All words generated must begin with a designated letter.
Attention	Digit-Symbol Modalities Test	Robbins et al. (1994)	Like a code, participants must match numbers with pre-determined symbols as quickly as possible
	Brief Attention Test	Schretlen, Bobholz & Brandt (1995)	A task of auditory perception requiring participants to record the digits and letters read aloud to them

Appendix C – Recruitment advertisement

RESEARCH INVOLVEMENT OPPORTUNITY

Calling all [organisation/ group/ congregation] members

I am currently training in Clinical Psychology at Canterbury Christchurch University and conducting an original piece of research. I am really hoping to give you the chance to be involved.

I'll be looking at how information about health conditions is remembered and understood. Previous research suggests that people's understanding and ability to remember information can change depending on how it is presented to them. I will be comparing ways of presenting information about health conditions to see if there is any advantage to one (e.g. video, written text or an audio recording) over another.

As we know, the population within the UK is ageing rapidly and it can become more difficult to understand and remember information as we get older. This can have negative consequences, particularly for those older people with health problems, as it can mean that they are less able to manage their difficulties. From this research my supervisor and I hope to increase knowledge about effective ways of communicating with older people and use this to improve future practice.

If you aged 18 – 40 OR 60+ and are interested in finding out more at this stage, please do get in touch either by email: j.a.harvey909@canterbury.ac.uk or leave a message for me on a 24-hour voicemail phone line at 01892 507673. Please say that the message is for me [Jess Harvey] and leave a contact number so that I can get back to you. Those who do decide to take part will be entered into 2 prize draws, each with the chance of winning a £50 voucher.

I look forward to hearing from you.

Jess Harvey.

Salomons Centre for Applied Psychology
Canterbury Christ Church University
Broomhill Road
Tunbridge Wells, Kent TN3 0TF

Appendix D - Example of experimental stimuli

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Appendix E – Information sheet for older adult participants

Information about the research

Does presenting health information through video benefit older adults' comprehension more than a written or audio format?

Hello. My name is Jessica Harvey and I am a trainee clinical psychologist at Canterbury Christ Church University. I would like to invite you to take part in a research study. Before you decide it is important that you understand why the research is being done and what it would involve for you.

Talk to others about the study if you wish.
(Part 1 tells you the purpose of this study and what will happen to you if you take part. Part 2 gives you more detailed information about the conduct of the study).

What is the purpose of the study?
The population of the UK is ageing rapidly and it can become more difficult to understand and remember information as we get older. This can have negative consequences, particularly for older people with health problems, as it can mean that they are not able to manage their difficulties as effectively. Previous research suggests that people's understanding and ability to remember information can change depending on how it is presented to them. We will be comparing ways of presenting information about health conditions to see if there is any advantage to one (e.g. video, written text or an audio recording) over another. We hope to use this information to increase knowledge about effective ways of communicating, with older people in particular, to improve future practice.

Why have I been invited?
I am interested in how you and 50 others (of around the same age and also of a different age) understand information about health problems.

Do I have to take part?
It is up to you to decide to join the study. If you agree to take part, I will then ask you to sign a consent form. You are free to withdraw at any time, without giving a reason.

What will happen to me if I take part?
If you decide you'd like to take part, I will contact you before we meet in person to ask whether you have any knowledge or experience of a list of different health conditions. When we meet, you will be asked to complete several tasks as best as you are able to. The tasks will involve reading words on a page, remembering information, problem solving and drawing. This will last for approximately 45 minutes. You will then be given information about a health condition and asked 6 questions about the condition afterwards, responding with 'yes', 'no' or 'I don't know'. Your participation in the study will then be finished and we will tell you more about the background research that the study is based on, what we are expecting the results will show and ask you briefly about your experience of doing the tasks. All of the data collected will be stored on a password encrypted USB flash drive and anything that might identify you will be removed (e.g. your name).

1. Where we meet will depend upon where you live and what is most convenient for you. If you live in Tonbridge or Tunbridge Wells, we will meet at the Salomons Centre for Applied Psychology. If you live in London then we will meet in a private room at

the Wellcome Collection Library. If you live in Jersey then we will arrange a suitable place for us to meet convenient to you, and if you live in Edinburgh, we will meet at Edinburgh University.

Expenses and payments
For taking part in the study your name will be entered into 2 prize draws, with the chance of winning a £50 voucher.

What will I have to do?
You and I will meet in a quiet room and go through some initial questions and activities. These will look at how you remember things and solve problems. You will then be shown some information about a health condition and asked a few questions about it. You will not be asked to give any personal information that you do not want to share and you may take a break if you need to.

What are the possible disadvantages and risks of taking part
You may feel uncomfortable or frustrated doing some of the learning tasks, especially if you do not think you did very well. These activities are not meant to be ‘catching you out’ or testing you specifically, we are interested in whether the way information is presented changes how well it is remembered. You will be able to take a break or stop completely if you’d like to.

What are the possible benefits of taking part?
We cannot promise the study will help you at the moment, but the information we get from this research will help improve the way information about health is communicated to older people, helping them to understand and remember it so they can manage their health more effectively.

What if there is a problem?
Just in case you have a problem during the study which can’t easily be sorted out, there is a procedure for making a complaint. The detailed information on this is given in Part 2.

Will my taking part in the study be kept confidential?
Yes. We will follow ethical and legal practice and all information about you will be handled in confidence. Very occasionally there can be a need to pass specific information on to others. The details about this are included in Part 2.

This completes part 1.
If the information in Part 1 has interested you and you are considering participation, please read the additional information in Part 2 before making any decision.

Part 2 of the information sheet

What will happen if I don't want to carry on with the study?

If you stop taking part in the study, we would still like to use the data collected up to that point. However, if you don't want us to use your responses at all, you have the right to request that they are taken out and destroyed.

What if there is a problem?

If you have any problems during or after our meeting, please do let me know. I will remind you that we can take a break or stop if you begin to feel uncomfortable and if this happens, please speak to me about it or ask to speak with the study's lead supervisor if you would prefer.

Complaints

If you have a concern about anything to do with the study, you can speak to me and I will try to answer your question directly (or find out more and then get back to you). You can also speak to me when we meet. My contact details are below:

Jessica Harvey
Trainee Clinical Psychologist
Salomons Centre for Applied Psychology
Salomons Campus, Canterbury Christ Church University
Broomhill Road, Tonbridge, Kent, TN3 0TF

If you feel as though this still hasn't been resolved and you want to complain formally, you can do this by contacting the Research Director for the Doctorate in Clinical Psychology:

Dr Paul Camic
Research Director, Doctorate in Clinical Psychology
Salomons Centre for Applied Psychology
Salomons Campus, Canterbury Christ Church University
Broomhill Road, Tonbridge, Kent, TN3 0TF
paul.camic@canterbury.ac.

Will my taking part in this study be kept confidential?

Yes. All information that includes your personal details (e.g. name or address etc.) will be kept securely in a locked drawer. You have the right to check whether the information collected about you is accurate and doesn't contain any mistakes.

All data you provide for the study (e.g. responses to questions and scores on tasks) will be anonymised (we will remove your name and replace it with a number or code) so that you could not be identified. It will be stored on a memory stick that requires a password to access the files. I am responsible for ensuring that all the data is kept safely and the password kept secure so the data is only accessed by me.

Other people may ask to look at the data collected once it has been anonymised. This may include the research supervisors Dr Edyta Monika Hunter and Dr Sarah MacPherson. Confidentiality will be maintained at all times in these cases.

The anonymous data will be kept securely at Canterbury Christ Church University for 5 years and destroyed once this time has ended.

What will happen to the results of the research study?

The findings from the research will be written into a report. If you would like a copy of the report, you can request one on the day that we meet or through using my contact details (above). The report will also be sent to an academic journal for publication. If it is accepted, then it will be available for other psychologists to read.

Who is organising and funding the research?

This research forms part of the assessment for the Doctorate in Clinical Psychology training programme and is funded by Canterbury Christ Church University.

Who has reviewed the study?

All research in the university is looked at by an independent group of people, called a Research Ethics Committee, to protect your interests. This study has been reviewed and approved by the Canterbury Christ Church University Research Ethics Committee.

Thank you for reading this information. You will be given a copy and a signed consent form to keep.

Further information and contact details

If you would like to speak to me and find out more about the study or have questions about it answered, you can leave a message for me on a 24-hour voicemail phone line at 01892 507673. Please say that the message is for me [Jess Harvey] and leave a contact number so that I can get back to you.

Appendix F – Information sheet for younger adult participants

Information about the research

Does presenting health information through video benefit older adults' comprehension more than a written or audio format?

Hello. My name is Jessica Harvey and I am a trainee clinical psychologist at Canterbury Christ Church University. I would like to invite you to take part in a research study. Before you decide it is important that you understand why the research is being done and what it would involve for you.

Talk to others about the study if you wish.
(Part 1 tells you the purpose of this study and what will happen to you if you take part. Part 2 gives you more detailed information about the conduct of the study).

What is the purpose of the study?
The population of the UK is ageing rapidly and it can become more difficult to understand and remember information as we get older. This can have negative consequences, particularly for older people with health problems, as it can mean that they are not able to manage their difficulties as effectively. Previous research suggests that people's understanding and ability to remember information can change depending on how it is presented to them. We will be comparing ways of presenting information about health conditions to see if there is any advantage to one (e.g. video, written text or an audio recording) over another. We hope to use this information to increase knowledge about effective ways of communicating, with older people in particular, to improve future practice.

Why have I been invited?
I am interested in how you and 50 others (of around the same age and also of a different age) understand information about health problems.

Do I have to take part?
It is up to you to decide to join the study. If you agree to take part, I will then ask you to sign a consent form. You are free to withdraw at any time, without giving a reason.

What will happen to me if I take part?
If you decide you'd like to take part, I will contact you before we meet in person to ask whether you have any knowledge or experience of a list of different health conditions. When we meet, you will be asked to read some words on a page as best as you are able to. You will then be given information about a health condition and asked 6 questions about the condition afterwards, responding with 'yes', 'no' or 'I don't know'. Your participation in the study will then be finished and we will tell you more about the background research that the study is based on, what we are expecting the results will show and ask you briefly about your experience of doing the tasks. All of the data collected will be stored on a password encrypted USB flash drive and anything that might identify you will be removed (e.g. your name).

Where we meet will depend upon where you live and what is most convenient for you. If you live in Tonbridge or Tunbridge Wells, we will meet at the Salomons Centre for Applied Psychology. If you live in London then we will meet in a private room at the Wellcome

Collection Library. If you live in Jersey then we will arrange a suitable place for us to meet convenient to you, and if you live in Edinburgh, we will meet at Edinburgh University.

Expenses and payments
For taking part in the study your name will be entered into 2 prize draws, with the chance of winning a £50 voucher.

What will I have to do?
You and I will meet in a quiet room and go through some initial questions and activities. These will look at how you remember things and solve problems. You will then be shown some information about a health condition and asked a few questions about it. You will not be asked to give any personal information that you do not want to share and you may take a break if you need to.

What are the possible disadvantages and risks of taking part
You may feel uncomfortable or frustrated doing some of the learning tasks, especially if you do not think you did very well. These activities are not meant to be ‘catching you out’ or testing you specifically, we are interested in whether the way information is presented changes how well it is remembered. You will be able to take a break or stop completely if you’d like to.

What are the possible benefits of taking part?
We cannot promise the study will help you at the moment, but the information we get from this research will help improve the way information about health is communicated to older people, helping them to understand and remember it so they can manage their health more effectively.

What if there is a problem?
Just in case you have a problem during the study which can’t easily be sorted out, there is a procedure for making a complaint. The detailed information on this is given in Part 2.

Will my taking part in the study be kept confidential?
Yes. We will follow ethical and legal practice and all information about you will be handled in confidence. Very occasionally there can be a need to pass specific information on to others. The details about this are included in Part 2.

This completes part 1.
If the information in Part 1 has interested you and you are considering participation, please read the additional information in Part 2 before making any decision.

Part 2 of the information sheet

What will happen if I don't want to carry on with the study?

If you stop taking part in the study, we would still like to use the data collected up to that point. However, if you don't want us to use your responses at all, you have the right to request that they are taken out and destroyed.

What if there is a problem?

If you have any problems during or after our meeting, please do let me know. I will remind you that we can take a break or stop if you begin to feel uncomfortable and if this happens, please speak to me about it or ask to speak with the study's lead supervisor if you would prefer.

Complaints

If you have a concern about anything to do with the study, you can speak to me and I will try to answer your question directly (or find out more and then get back to you). You can also speak to me when we meet. My contact details are below:

Jessica Harvey
Trainee Clinical Psychologist
Salomons Centre for Applied Psychology
Salomons Campus, Canterbury Christ Church University
Broomhill Road, Tonbridge, Kent, TN3 0TF

If you feel as though this still hasn't been resolved and you want to complain formally, you can do this by contacting the Research Director for the Doctorate in Clinical Psychology:

Dr Paul Camic
Research Director, Doctorate in Clinical Psychology
Salomons Centre for Applied Psychology
Salomons Campus, Canterbury Christ Church University
Broomhill Road, Tonbridge, Kent, TN3 0TF
paul.camic@canterbury.ac.

Will my taking part in this study be kept confidential?

Yes. All information that includes your personal details (e.g. name or address etc.) will be kept securely in a locked drawer. You have the right to check whether the information collected about you is accurate and doesn't contain any mistakes.

All data you provide for the study (e.g. responses to questions and scores on tasks) will be anonymised (we will remove your name and replace it with a number or code) so that you could not be identified. It will be stored on a memory stick that requires a password to access the files. I am responsible for ensuring that all the data is kept safely and the password kept secure so the data is only accessed by me.

Other people may ask to look at the data collected once it has been anonymised. This may include the research supervisors Dr Edyta Monika Hunter and Dr Sarah MacPherson. Confidentiality will be maintained at all times in these cases.

The anonymous data will be kept securely at Canterbury Christ Church University for 5 years and destroyed once this time has ended.

What will happen to the results of the research study?

The findings from the research will be written into a report. If you would like a copy of the report, you can request one on the day that we meet or through using my contact details (above). The report will also be sent to an academic journal for publication. If it is accepted, then it will be available for other psychologists to read.

Who is organising and funding the research?
This research forms part of the assessment for the Doctorate in Clinical Psychology training programme and is funded by Canterbury Christ Church University.

Who has reviewed the study?
All research in the university is looked at by an independent group of people, called a Research Ethics Committee, to protect your interests. This study has been reviewed and approved by the Canterbury Christ Church University Research Ethics Committee.

Thank you for reading this information. You will be given a copy and a signed consent form to keep.

Further information and contact details
If you would like to speak to me and find out more about the study or have questions about it answered, you can leave a message for me on a 24-hour voicemail phone line at 01892 507673. Please say that the message is for me [Jess Harvey] and leave a contact number so that I can get back to you.

Appendix G – List of health conditions in the experimental stimuli

Dear [participant]

Thank you for agreeing to be involved in my study. As we discussed, you will be asked to learn information about health-related conditions.

From the list below, please indicate which (if any) of the following you have knowledge or experience of already. 'Knowledge or experience of' includes any of the conditions which either yourself or a close friend/family member have experienced, or any you think you have more knowledge about than other people in a 'general knowledge' sense e.g. from working in a health-related profession.

Multi-Infarct Dementia
Parkinson's Disease
Pacemaker care
Urinary retention
Stroke
Diabetes
Coronary bypass surgery
Chemotherapy
Dividing pills
Gout
Gastroparesis
Calcium Channel Blocking Agents
Hyperthermia
Age-Related Macular Degeneration
Blood glucose levels
Blood glucose in relation to food

Many thanks and I look forward to meeting with you on [date] at [time]

It is possible that looking at the above list and thinking about some of these conditions may bring up difficult feelings. If this is something you experience, please remember that you do not need to continue with participating if you do not want to. You can also contact me to discuss this if you would like.

If you have any questions or queries about participating in this research, please remember that you can contact me via email (j.a.harvey909@canterbury.ac.uk) or at Canterbury Christ Church University using the address below.

Jess Harvey
Trainee Clinical Psychologist
Salomons Centre for Applied Psychology
Canterbury Christ Church University
Broomhill Road
Tunbridge Wells, Kent TN3 0TF

Appendix H – Participant consent form

Canterbury Christ Church University

Salomons Centre for Applied Psychology

Study Number: V:\075\Ethics\2015-16
Participant Identification Number for this study: OA1

CONSENT FORM
Title of Project: Effects of age on a multimodal health information task
Name of Researcher: Jessica Harvey

Please initial box

1. I confirm that I have read and understand the information sheet for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. I fully understand what I'm being asked to do. ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my legal rights being affected. ☐

3. I understand that my anonymised data may be looked at by the lead supervisors, Dr Edyta Monika Hunter and Dr Sarah MacPherson. I give permission for these people to have access to my data. ☐

4. I agree to take part in the above study. ☐

5. I give permission for my anonymised data to be submitted in a thesis to Canterbury Christ Church University and to a journal for publication. ☐

Name of Participant____________________ Date________________

Signature ___________________

Name of Person taking consent ______________ Date_____________

Signature ____________________

Appendix I - Ethical approval letter

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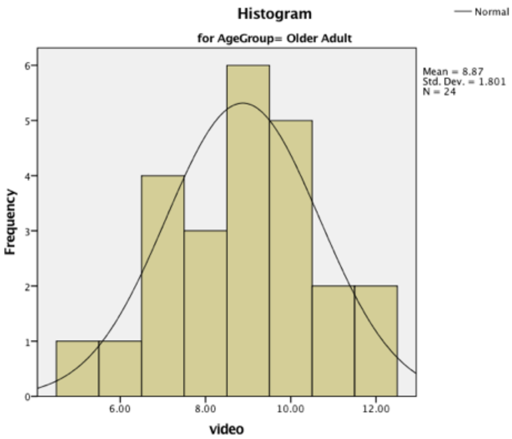
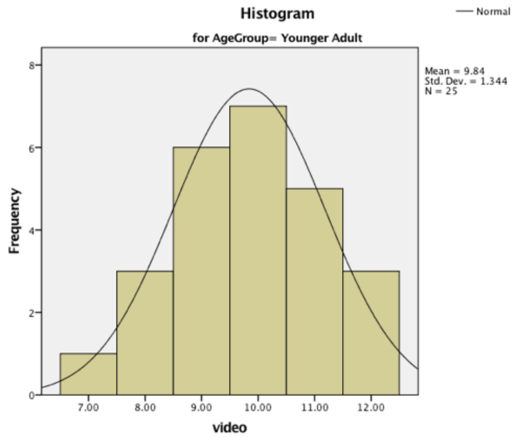
Appendix J – Histograms indicting normal distribution of older and younger participants' scores on the health information task

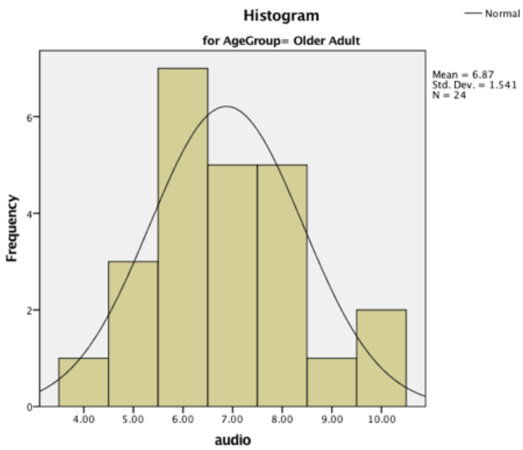
Video stimuli – Older adult



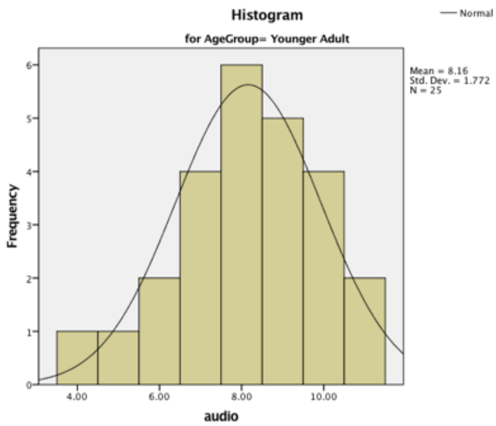
Video stimuli – Younger adult



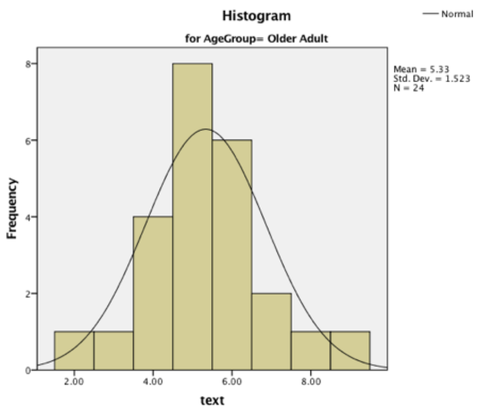
Audio stimuli – Older adult



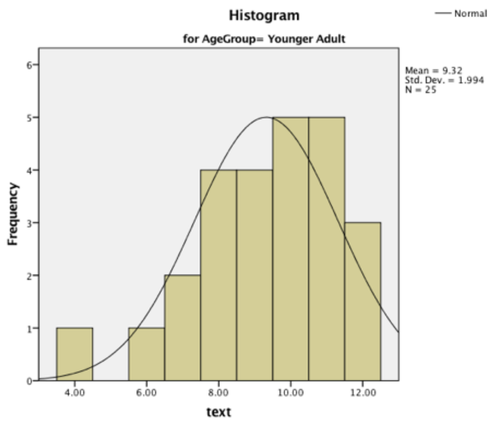
Audio stimuli – Younger adult



Text stimuli – older adult



Text stimuli – Younger adult



Appendix K – Letter to Ethics Board confirming completion of the study and summarising its findings

This has been removed from the electronic copy

Appendix L – Participant feedback letter

Canterbury Christ Church University

Salomons Centre for Applied Psychology

Dear .....

Thank you again for participating in my research project. The project looked at whether health information presented in different formats (video, audio or text) could change how well people could answer questions about it afterwards.

I am writing to you to remind you of what the purpose of the study was and to let you know what we found out from the results.

It can become more difficult to understand and remember information as we get older. This can have negative consequences, particularly for those older people with health problems. It can mean that they are less able to manage their difficulties. Some previous research suggests that older people are able to perform better on a range of tasks when they are shown information to more than one sense at a time. For example, audio-visual information, compared to audio or visual information shown on its own. It has also been suggested that older people could benefit more than younger people from being shown information in two formats at the same time.

My research project tested whether being shown information about health conditions on a video, helped older people to answer questions about the information as well as younger people did. This was compared to how older and younger people answered questions about the information when it was just listened to, or read.

The study results suggested that being shown information on a video did help older people to answer questions about it better than being shown audio or text information. The findings also showed that being shown information on a video meant that older people performed about as well as younger people on the task. However, older people performed more poorly than younger people when only shown information by audio or text.

We think this might be because older people absorb more information than younger people when it is shown to more than one sense at a time. The findings might also be because older people are able to compensate for a possible decline in their individual senses (e.g. vision and hearing). I have suggested that future research investigates this further, and how audio-visual information could be used by professionals to support older people in managing their health.

Thank you very much for participating in the research. If you have any questions, please do contact me by email: j.a.harvey909@canterbury.ac.uk.

Yours sincerely,

Jess Harvey
Trainee Clinical Psychologist
Salomons Centre for Applied Psychology
Canterbury Christ Church University
1 Meadow Road
Tunbridge Wells
Kent, TN1 2YG

Appendix M - Author guideline notes for chosen journal: Psychology and Aging

Manuscript Preparation
Prepare manuscripts according to the *Publication Manual of the American Psychological Association* (6th edition). Manuscripts may be copyedited for bias-free language (see Chapter 3 of the *Publication Manual*).
Review APA's Checklist for Manuscript Submission before submitting your article.
Double-space all copy. Other formatting instructions, as well as instructions on preparing tables, figures, references, metrics, and abstracts, appear in the *Manual*. Additional guidance on APA Style is available on the APA Style website.

Length

Articles

Articles do not typically exceed 8,000 words, excluding references, tables, and figures. Shorter manuscripts are equally welcome.
Articles exceeding the 8,000 word limit may be considered if they offer an especially novel theoretical framework, or complex methodology or statistical approach that requires more extensive exposition.

Brief Reports

The Brief Report format is reserved for particularly "crisp," theoretically noteworthy contributions that meet the highest methodological standards.
Brief reports are typically no longer than 3,500 words, excluding references, tables, and figures, and include no more than two tables or figures.
Papers in this format differ in length from regular articles, but not in rigor.
Below are additional instructions regarding the preparation of display equations, computer code, and tables.

Title Page

The first manuscript page is a title page, which includes a title of no more than 12 words, the author byline and institutional affiliation(s) where the work was conducted, a running head with a maximum of 50 characters (including spaces), and the author note.

Abstract and Keywords

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